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ANNALS

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The Entomological Society of America

Volume X MARCH, 1917 Number 1

FOSSIL INSECTS.*

By T. D. A. Cockerell.

In these serious days, it seems just a little grotesque that I should cross half a continent to address you on a subject so remote from the current of human life as fossil insects. The limitations of our society do indeed forbid such topics as the causes of the war or the evil effects of intercollegiate athletics; but I might have chosen to discuss lice or mosquitoes—any of those insects whose activities have before now decided the fate of nations. My excuse for avoiding these more lively topics only aggravates the offense, for it is the fact that I have never given them adequate attention, but have in the past ten years occupied myself with matters having for the most part no obvious economic application.

There is, however, another point of view. Many years ago I had the good fortune to meet the eminent ornithologist, Elliott Coues, at Santa Fe. We spent a considerable part of the night discussing a variety of subjects, from spiritualism to rattlesnakes, and when we parted he made a remark which those who knew him will recognize as characteristic. He said, "Cockerell, I really believe that if it had not been for science, you would have been a dangerous crank!" Surely experience and history alike confirm the essential sagacity of the observation, as applied not merely to your lecturer, but to mankind in general. How often has our poor human race exhibited the qualities of a dangerous crank, owing to the lack of those which devotion to science may stimulate! Has it not been so

*Annual Address before the Entomological Society of America, delivered at New York, December 28th, 1916.

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in Europe in these dreadful days? It is true that science is being accused as the handmaiden of war, is blamed for the many diabolical inventions for taking human life; but these things are aside from the great current of scientific thought, and it would be equally just to accuse language, which is at the very root of human progress, because forsooth it has been the vehicle of every hateful emotion.

The pursuit of science, by which we mean the effort to understand nature, is akin to religion, because it enables us to see the world as part of the universe and ourselves and our affairs as particular examples of universal phenomena. We do not thereby lose our self respect; on the contrary, it should be increased by the consciousness of having a part in the affairs of the cosmos. It is some such feeling as this, not usually defined in words, which keeps the naturalist to his task. People ask him, why do you labor over that microscopical animal, of no apparent interest to any one? They might as well ask a bricklayer why he thinks it worth while to lay any single brick of some mighty building.

The general sense, the pious belief, that every part of the scientific structure is worth while, has been greatly heightened in recent years by researches in genetics. It is a marvelous thing that we can reason from Mendel's peas to human life; that Jenning's protozoa should be significant for the study of sociology. Thus we come to the conviction that even a fossil cockroach from the coal mines of Pennsylvania has some story to tell which may serve us in our day. Entomologists are not as humble as they were in my young days, but I fear they do not yet appreciate the full significance of their science in relation to the philosophy of life. The enormous variety of insect life, exhibiting innumerable adaptations to all sorts of conditions, gives us unparalleled opportunities. What New York is to the sociologist, the class Insecta must be to the naturalist. A single species of insect, *Drosophila melanogaster*, has enabled Morgan and his associates to largely reconstruct our ideas concerning the mechanics of heredity; to give us well ascertained facts in place of much vague speculation.

It is, however, from the *comparative* morphology and physiology of insects that we may expect to learn most about the phenomena of evolution. I recall being present several years ago at a meeting at Boston, when Professor J. C. Bradley

exhibited a number of figures of hymenopterous wings, and offered some opinions concerning the evolution of the venation. In the discussion which followed, the criticism was made that all the species concerned were living ones, that obviously they could not be thought of as ancestral to one another, and consequently any attempt to see in them a true evolutionary series must be futile. This sounded reasonable, but it did not take into account the fact that while *species* may all be recent *genera* of insects are old, and of extremely different antiquity. This is one of the lessons we have learned from the study of fossil insects, and it teaches us that the existing insect fauna is extremely rich in ancient types, which do really illustrate evolutionary sequence. The reason for this is rather obvious. The stream of insect life branches in a complex manner and owing to the enormous diversity of possible adaptations, resulting from the diversity of physical conditions, of food and of enemies, very many of the products of evolution have been preserved without important modification. This is especially striking when we regard *characters* rather than *species*, and observe differences in the minute structure of the tegmina of Palæozoic cockroaches, corresponding with similar differences to be found in their living representatives. Just as the infinite variety of higher animal life has been built up from a scarcely altered fundamental series of *tissues*, so families, genera and species have arisen not so much from entirely new developments, as from the shuffling of ancient characteristics. There is, of course, no doubt that definite progressive evolution has taken place among the insects just as among the vertebrates; thus the greatly modified mouth-parts of bees and butterflies, adapted for sucking the nectar of flowers, certainly came into existence after the Palæozoic, and when plants with suitable corollas had developed or were developing.

There is no doubt that the Mesozoic, the period of the rise of the higher plants, saw a remarkable development of insect life, concerning which we know too little, owing to the relative scarcity of fossils. It does not appear, however, that there is much if any innate tendency to progress, without reference to changing conditions. During the Tertiary epoch there seems to have been little forward evolution, and in the north temperate regions we may detect a very perceptible contraction and impoverishment of the fauna since the Miocene. In the absence

of a progressive movement, there has nevertheless been much of the shuffling already mentioned, producing a great mass of specific forms, while many genera have become extinct. Aside from these general questions, we may value the evidence afforded by fossil insects for the light thrown on geology and paleogeography . In the first place, although the *genera* of insects are of long duration, the *species* appear to be short lived. The best evidence for this opinion comes from the fact that strata supposed by the geologist to be of nearly or quite the same age, often contain insect-faunulæ in which the species are all distinct. This may be partly due to different ecological conditions and to migrations, but it certainly is due in part to the comparatively rapid evolution of insect species. This is especially proved by the Pleistocene beetles studied by Scudder, which are closely allied to modern species, yet distinct. Professor Wickham is now engaged in the study of many additional Pleistocene beetles, and though his work is not finished, he kindly informs me that "they seem to be pretty nearly all different, subspecifically at least, from those of today."

Owing to the complexity of insect life and the facilities these animals have for getting about, faunæ are constantly in a state of flux, species locally dying out, and others coming in. Thus there can be little doubt that complete collections made in any locality at intervals of one hundred years would be appreciably different; except perhaps in the tropics, where conditions are likely to be more uniform. It is doubtless on account of this fact that we not rarely find non-functional examples of "mimicry," which are offered as obstacles to the view that mimicry has any adaptive significance. It is evident that the almost kaleidoscopic insect fauna must present characteristics which are to be understood in relation to the past rather than to the present. It results from all these considerations that fossil insects, when they can be obtained in any numbers and from different levels, afford a very delicate index to the details of stratigraphy, probably surpassing in this respect every group of organisms except mammals, which are not available for the purpose until we reach the Tertiary. The obvious objection to the use of insects in this manner arises from their comparative scarcity; but this has been exaggerated, and every year brings to light new localities. In particular, the Pennsylvanian (Upper Palæozoic) coal bearing strata of Maryland, Pennsyl-

vania and West Virginia have lately been found by Mr. H. Bassler to contain numerous faunulæ, mostly cockroaches, which I have been permitted to study. Scudder and Handlirsch had already observed that practically every Palæozoic locality yielded different species, and I have also found this to be the case. Considering the number of species and localities discovered by Mr. Bassler in a couple of years or so, we may reasonably expect eventually to have a very good detailed knowledge of the insects of the Pennsylvanian, and thereby have the means of elaborating a very accurate stratigraphy of the anthracite coal region. The tendency of all these studies is to enlarge our conception of the duration of the Pennsylvanian, which must represent an enormous amount of time. The main outstanding question now is, can we not only distinguish all these cockroach faunulæ—as we certainly can—but also place them, from the evidence afforded by the insects alone, in the right order? In other words, can we recognize a direct forward evolution, or are we again confronted by a shuffling process? Before attempting to answer this, we must get rid of the idea that regular progressive development necessarily occurred, and only waits to be detected. In the Tertiary, were it possible to restore the faunæ of a million years ago to life, and place them beside those existing now, there are certainly several groups, at least, in which no entomologist could distinctly affirm which was the more primitive. The best he could do would be to point out that whereas both lots contained archaic genera, there were rather more of these in the older series; and to do this he would need very complete materials.

Returning now to the Palæozoic fauna we find, as Handlirsch has pointed out in several papers, that insect life begins, so far as we know it, with that remarkable group called Palæodictyoptera. The so-called Silurian insects are clearly valueless, and the exact age of the oldest Palæodictyoptera is still a matter of dispute; Mr. G. F. Matthew still adheres to the opinion that the remains from St. John, New Brunswick, are of Devonian age. He points out that cockroaches are entirely absent, that Devonian genera exist among the accompanying plants, and that a later (Mississippian) facies is due to the fact that the deposits represent an old delta plain, whereas other known Devonian plants are from what was hilly country or sea-coast. On the other hand Kidston and David White,

judging from the plants, would refer the beds to the Carboniferous, even later than the Mississippian. Leaving these matters undecided, there are still some important facts which admit of no dispute. In the first place, the insects, like the higher flowering plants, first appear on the scene in a highly developed condition. It is true that the Palæodictyoptera are very primitive as compared with our modern Lepidoptera, Hymenoptera or Coleoptera, but in their own particular line, they represented a wonderful development of insect life.* There was evidently great variety of form and structure, while many of the species reached an enormous size. The anterior wings of *Archæoptilus gaullei* Meunier are estimated to be 18 cm. long, and as the distance between the wings is 24 mm., the total expanse is 384 mm.—over 15 inches.† Truly, there were giants in those days! This exuberant type flourished during a period *before the rise of the Blattids*, but extended into the Pennsylvanian, where, as at Mazon Creek, Illinois, it is accompanied by a rich fauna of Protorthoptera and Blattoids. It existed equally in Europe and North America, and in both areas gradually disappeared during the Upper Carboniferous or Pennsylvanian. The disappearance of the Palæodictyoptera is coincident with the rise of the Blattoids; and in America, at least, we soon come to a period when the Blattoids were dominant, to the total exclusion of Palæodictyoptera, and the great reduction of all other insects. This lasts to the end of the Pennsylvanian, and perhaps into the Permian; but in the Permian strata of Kansas, in which Sellards obtained a very rich insect fauna, Blattoids are in the minority, and other insects are numerous. Thus we have certainly three great periods, so far as the insects are concerned; one prior to the appearance of Blattoids, one during which the Blattoids and Palæodictyoptera and Protorthoptera existed together, and one during which the Blattoids were dominant almost to the

*Reconstructions of these insects must not be taken too seriously. In his very valuable and suggestive paper on the Ancestry of Insects (Am. Jn. Sci., Nov., 1916), Mr. J. D. Tothill copies a couple of figures from Handlirsch, which that author states to be diagrammatic reconstructions. Mr. Tothill, however, makes Handlirsch's hypothetical and reconstructed Palæodictyopteran larva a *Stenodictya*, and proceeds to discuss the larva of that genus, as if it were well known.

†The largest known insect, *Meganeura monyi* Brongniart, from the Upper Carboniferous of Commentary, France, is stated to have had an expanse of fully 70 cm., or about 2 ft. 4 inches. Handlirsch refers it to the Protodonata, a type prophetic of our modern dragon-flies.

exclusion of other types. If we go into the Permian, we have still another great period, in which the insects were smaller, and becoming more diversified, with the Blattoids in the minority.

This does not by any means exhaust our catalogue of sequences. Scudder in 1896 gave an elaborate table showing that during Upper Carboniferous and Permian time there was a fairly regular decrease in the size of cockroaches, so that if one had a number of faunulæ, the average size of the members would be an index to the relative ages of the strata. Since Scudder's time some of the opinions of geologists have changed, and from the recent material which has come in, I do not believe that this class of evidence is as valuable as it seemed to be; yet it is probably not without significance. More important in some respects is probably the relationship between the Archimylacrid and Mylacrid Blattoids, two groups easily distinguished as a rule by characters of the venation. The Archimylacrids appear to be the older, and these, along with the Palæodictyoptera, abound both in Europe and America. The Mylacrids, on the other hand, are essentially American, and appear to have developed during a period when there was no land connection between the Old and New Worlds. The proportion of Mylacrids in a given fauna is probably highly significant for stratigraphy; and the whole group emphasizes the fact already suggested by other evidence, such as that obtained by Petrunkevitch from a study of the Arachnids, that during middle Pennsylvanian time, at least, the evolution of the American fauna was wholly independent of that of Europe. Thus, as we investigate these matters, we do seem to observe a distinct procession of events, which cannot be without significance for geology or evolution.

The Permian, or closing period of the Palæozoic, was marked in North America by an elevation of the land surface and a general reduction of temperature. This continued into the Mesozoic. The new conditions appear to have been unfavorable to Blattoids, and to have given opportunity for the development of diverse types of smaller insects, many of which passed their early life in fresh water. There was at the same time a remarkable development of terrestrial cold-blooded vertebrates. The new start thus made probably may be taken as representing the foundation of the modern insect-fauna, though several impor-

tant orders did not appear until much later. The appearance of the Coleoptera very early in the Mesozoic, with perfectly characteristic elytra having sometimes quite modern-looking color-patterns, is surprising and not at present to be explained. The Diptera, Lepidoptera and Hymenoptera all came in later. The Upper Mesozoic or Cretaceous strata have as yet proved extremely poor in insect remains; less than fifty species are known, and most of these are quite worthless objects. This is very unfortunate, as it is probable that during this period most of the modern families of insects had their origin. Nothing would do more to throw light on the relationships of living insects than the discovery of a rich Cretaceous fauna. It is surprising that among the numerous Cretaceous plants, for example in the Laramie of Colorado, where the preservation is so good that it is sometimes possible to peel off the epidermis of leaves, insects hardly ever occur. A Blattoid (*Stantoniella*) was indeed found in the Judith River beds of Montana, but it remains unique. An astonishing find was that of an apparent Fulgorid (*Petropteron*) in the Pierre Cretaceous, a marine formation, at Boulder, Colorado. It had fallen into the sea, and been buried in the mud of the littoral zone. The most hopeful discovery, so far, is that of a very good Trichopteron (*Dolophilus*, a genus still living) in Upper Cretaceous amber in Tennessee. If an insect fauna can be found in this amber it will be of extraordinary interest and value.

Attention should be called to a very interesting paper by Mr. R. J. Tillyard, published this year by the Queensland Geological Survey. He describes a number of Australian fossil insects, and in particular a supposed Lepidopteron, *Dunstania pulchra*, from the Trias, said to be the oldest Lepidopteron known. This has since been discussed by Meyrick, who concludes that it may be Homopterous, but cannot be Lepidopterous. As he remarks, the thickened wing-margin is unlike that of Lepidoptera. There is certainly a suggestion of a Cicada-like form in the region of the cubitus.

The Tertiary epoch represents perhaps four million years, certainly much less than half the Mesozoic. At the close of the Mesozoic there was an uplift similar to that marking the Permian, and during Tertiary time this has been maintained, with minor oscillations, while the continental climates in north temperate regions have become colder and more arid. Thus

in Colorado the end of the Cretaceous marks the emergence of the country east of the mountains from the sea, and the transitional marsh conditions, with an abundance of luxuriant vegetation, produced the deposits now yielding the Laramie coal. About this time the great dinosaurs died out, and the higher mammals began to show what they could do. The story of Tertiary mammalian life is a wonderful one, and our knowledge of the details is now very considerable. Reasoning from analogy, we might expect that the Tertiary would show a progressive movement in insect evolution comparable with that marking the end of the Palæozoic and beginning of the Mesozoic. It is a fact that on comparing the Tertiary insects with the Mesozoic, there are differences in part resembling those observed among the mammals. The Tertiary insect fauna is essentially modern, indeed it may be said that we have it still with us. It is far richer and more varied than that of the Mesozoic, especially in such groups as Lepidoptera and Hymenoptera. In the flora, we have a remarkable expansion and development of the herbaceous type, but no radical modification comparable with the origin of the higher flowering plants. So also among the insects, we have a great increase in variety, an immense series of adaptive modifications, but nothing to be compared with the origin of the Coleoptera, Diptera, Lepidoptera and Hymenoptera. Has nature partly exhausted her possibilities, new adaptations being limited owing to the very success of the older ones?

As students of particular groups of insects, we are keenly interested in the evolution of the modern families and genera. As we look at the known Tertiary forms, we are impressed by the number of genera identical with or closely related to those now living, and the extreme scarcity of extinct families, or even subfamilies. There is this to be said, however, that the oldest extensive fauna in Europe is that of the Baltic Amber, in the Lower Oligocene. Back of that, during the vast period represented by the Eocene and Paleocene, there are only a few scattered remains, the most instructive being a beautiful dragon fly (*Triæschna gossi* Campion) from the Upper Eocene (Bagshot Beds) of Bournemouth. In this country we are more fortunate, since the extensive deposits of Green River in Wyoming and White River in western Colorado and eastern Utah are certainly Eocene, not Oligocene as has been sometimes supposed. There

are also other Eocene localities, such as that near Rifle, Colorado; and quite recently a small series of Coleopterous elytra has been obtained in Colorado in beds which are probably quite near the base of the Tertiary. The value and importance of these older Tertiary insects has never been appreciated; Scudder, who described nearly all of them, was not aware of their relative antiquity. In his work on the Tertiary weevils Scudder brings out very clearly the radical difference between the Florissant Fauna and what he calls the Gosiute Fauna, although "the deposits of both (Florissant and the Gosiute Lake) are presumably of Oligocene age." When we consider that according to the best information we now possess Florissant is Miocene and the Gosiute Lake Eocene, all surprise at the absence of species common to both vanishes.

The Rocky Mountain Eocene insects present a rather remarkable assemblage, not so much on account of what is present, as for the absence of important groups. Coleoptera, Diptera and Hemiptera are numerous, but prevailingly small. There are a few Orthoptera and some good Odonata. A few very poorly preserved ants were described by Scudder, together with some parasitic Hymenoptera and a good sawfly; but no bees have ever been obtained, and there is only a single fossorial wasp. No Lepidoptera have yet been seen. Perhaps the most interesting Dipteron is an Oestrid, represented by numerous larvæ.* Various families of the higher Diptera were represented by genera which still exist. It is possible that the conditions of deposition partly explain the character of this Eocene fauna, or series of faunulæ, and it is reasonable to expect that further collecting will greatly modify the statistics. At the same time we are lead to ask whether the complete modernization of Tertiary insect life had taken place at this early date; or rather, granting that the fauna so far as it goes is quite modern in aspect, whether the exuberance of types so characteristic of later times had yet developed. The condition of affairs may, in short, have been analogous to that observed in the Mammalia, which had by this time established the modern outlines, but had much development and diversification

*Dr. J. Bequaert calls my attention to the resemblance between these larvæ and those of the African genus *Dermatoestrus*. The imago of *Dermatoestrus* is unknown.

still ahead. The parallel is of course not exact, since insect genera are much more stable and long lived than those of mammals.

The fauna of Prussian Amber, of Oligocene age, is extraordinarily rich and beautifully preserved, the specimens resembling mounts in Canada balsam. In the museum at Konigsberg are over 100,000 specimens, while many exist elsewhere. Fake specimens are occasionally seen in collections, or specimens supposed to be in amber, but really in African Copal, of post-tertiary age. Putting aside all these, the perfectly genuine Oligocene amber collections are enormous, though only partly worked up. Ulmer, in a most remarkable work, has monographed the Trichoptera; Wheeler has done a like service for the ants; Meunier has described a great series of Diptera, and other authors have discussed smaller groups. Edmund Reitter has made a preliminary survey of the Coleoptera, indicating the recognisable families and genera, and a considerable number of apparently new genera not yet described or named. On looking over the lists, one notices first of all the richness of the fauna, the great abundance of genera and species. During mid-Tertiary times, the climate of the present Holarctic region was warmer than at present, and conditions seem to have been exceptionally favorable for an abundance of insect life. Since that time, the glacial period, or rather succession of glacial periods, has destroyed or driven out very many types, so that today we dwell in a relatively impoverished world, so far as the North Temperate region is concerned. Another remarkable thing is the lack of progress exhibited in the two million years or so since the time of the amber. Wheeler, referring to the ants, says that since the amber "the family has not only failed to exhibit any considerable taxonomic or ethological progress, but has instead, suffered a great decline in the number of species and therefore also in the variety of its instincts, at least in Europe." Ulmer, speaking of the Trichoptera, says that the amber fauna is quite as highly developed as that of modern times. The presence of numerous extinct genera in all groups bears witness rather to the faunal contraction already mentioned than to any uniform and general advance of organization. There are, indeed, some archaic genera, but such also exist today. It must be said, however, that the bees, which I have studied, *all* belong to extinct genera, and

on the whole are distinctly less advanced than the higher modern ones. There are, however, many modern genera of bees more primitive than any yet found in amber. Meunier's catalogue of amber Diptera is remarkable for the great numbers of Tipulidæ, Cecidomyiidæ, Mycetophilidæ, Chironomidæ, Psychodidæ, Phoridæ, Empididæ, and Dolichopodidæ. On the other hand, Asilidæ, Bombyliidæ, and many families of higher Diptera are very rare or absent. This looks at first like a certain indication of the relatively undeveloped character of the Dipterous fauna of the Oligocene, and is quite in line with the evidence from the much earlier Eocene of North America.

It will be noted, however, that precisely those forms are present which would most easily and probably be caught in the amber, and there is no possible doubt that the list fails to represent large elements in the fauna. This is well shown by the scarcity of Lepidoptera, which undoubtedly abounded in those days. The Florissant Coleoptera, of Miocene age, much later than the Baltic amber, are remarkable for the prevailingly small size of the species, and here we cannot so easily ascribe the peculiarity to the method of preservation. It would doubtless be true, under almost any conditions, that the larger and stronger forms would be most likely to escape the destructive influence; yet we are left with a residue of feeling that the average size of the insects actually was less than at present. Many of the larger species in the present fauna represent essentially southern, or even tropical groups, and it may well be believed that though their ancestors existed in Oligocene and Miocene times, they had not yet spread northwards. The very impoverishment of the fauna during glacial times, with the subsequent amelioration of the climate, may have given opportunities to southern types, which during the mid-Tertiary were barred out by an already rich and aggressive fauna occupying the territory.

Also Oligocene, but perhaps later than the amber, is the rich deposit at Gurnet Bay, in the Isle of Wight. The specimens are preserved in solidified mud, absolutely without compression. The materials are of particular importance, not only as coming from a distinct locality, but on account of the quite different medium in which they are preserved. So far, 25 Diptera, 4 dragon flies, 8 ants, 1 Diapriid, 1 wasp, 4 Homopteron, 1 Lepidopteron, 2 termites, a *Sisyra*, a *Raphidia* and an *Aeolothrips*

have been described. The list is not long enough to prove much, but the series has a modern aspect. The ants include species of *Oecophylla*, now especially characteristic of tropical Asia and Australia; while the termites belong to the primitive Australian genus *Mastotermes*. The wasp, assigned to the Philanthidæ, may perhaps belong to the Mutillidæ (Myrmosinæ), as Mr. S. A. Rohwer has suggested in correspondence. I cannot recognize any of the species as being identical with those in amber. A very large collection of these Gurnet Bay insects is in the British Museum; and while the majority cannot be determined, it is certain that among the 2,500 specimens there are sufficient good ones to give us a fair idea of the fauna. I examined 170 of these specimens and found twelve describable new species, not including the Coleoptera, which were numerous. At this rate, the whole collection may perhaps be expected to yield at least 200 species. I described 33 species from the Lacoe collection in the U. S. National Museum; these came originally from the Brodie collection, which is now in the British Museum. Although they were supposed to be "duplicates," they were apparently selected with judgment, and as no serious attempt has ever been made to sort the species among the Gurnet Bay fossils, it is very probable that many of the Lacoe series are not represented in the larger collection. All the Gurnet Bay insects of which I have any knowledge were collected many years ago by the Rev. P. B. Brodie, and I do not know whether the deposit is still workable. Arrangements are being made at the British Museum to have the Gurnet Bay collection worked up by various specialists; Mr. Donisthorpe has already undertaken the ants.

Baltic amber is not the only source of amber insects. Amber is found on the east coast of England, and specimens containing insects are in the museum of Cambridge University. One piece contains a couple of modern honey bees, and is, I fear, a fake; but some of the others look genuine. The species still await critical study and description. Shelford described some Blattids from Miocene amber obtained at Stettin; one of these he could not distinguish from the living *Euthyrrhapha pacifica* (Coquebert), which is at present found in South America, Africa and Polynesia. Sicilian amber, also of Miocene age, and therefore much later than Baltic amber, has yielded some very interesting insects, especially a remarkable series of ants and a Meliponine bee.

Very recently, Mr. R. C. J. Swinhoe has sent me many specimens of Burmite, or Burmese amber, containing insects. This material occurs in clay beds of Miocene age, but it is evident that the amber was washed into them from higher levels, and it is not impossible that it is much older. The insects, so far as yet examined, have rather a primitive aspect, but the number of species as yet available is small. I find a Termite (*Termopsis*), a Psocid (doubtfully referred to *Psyllipsocus*), an Hemipteron of the interesting genus *Enicocephalus*, a *Trigonalys*, two extinct genera of Evaniidæ, both very small, an extinct genus of Empididæ, a *Sciara* and a species of the Psychodid genus *Trichomyia*. It is expected that more of this amber from Burma will be available, and we may ultimately get a good idea of a Tertiary insect fauna in tropical Asia.*

It is not necessary to review the quite numerous deposits containing Miocene insects in Europe, but we cannot overlook our own wonderfully rich Florissant shales. A short distance west of Pike's Peak, resting on a base of granite, is an ancient lake-basin containing laminated shales full of insect and plant remains. The preservation of the specimens is often excellent, even such minute and fragile creatures as Aphids being represented by numerous recognizable genera and species. The number of described species is now about 1300; by far the largest Miocene insect fauna known in the world. The corresponding European deposit, at Wangen on the Rhine, has 465 described species, but many others remain undescribed in the University at Zurich. It is certain, however, that were all the Wangen fossils worked up, the series would still fall far short of that of Florissant.

The presence of certain types which probably reached America from the Old World, and the absence of any distinct Neotropical element, suggest that the Florissant beds were laid down subsequent to the beginning of the migration from Asia by way of what is now Behring Strait, but before North and South America were connected; that is to say, in the latter half of the Miocene. Should mammals be found at Florissant, early forms of the elephant group may perhaps be expected. Perhaps the most remarkable of all the Florissant insects is the genus *Glossina*, today known as an inhabitant of tropical Africa,

* Since this was written a new lot has come to hand, including many species, one an Elaterid beetle nearly 20 mm. long.

where it carries parasites which cause fatal diseases to man and animals. No less than four species of tsetse flies have been found fossil at Florissant; and the extraordinary thing is, that these alone represent the higher Muscoids in the fauna, there being no true Muscidæ, no Tachinidæ, Dexiidæ or Sarcophagidæ. Anthomyiidæ and various acalyptrate families appear to be rather common. Bombyliidæ are abundant and very varied, consisting of twelve genera now extinct, a doubtful *Geron*, and a species of the living but rare and widely scattered genus *Dolichomyia*. It is possible that the Bombyliidæ then occupied, as parasites, the position now chiefly taken by the Tachinidæ. The Anthracine Bombyliids, now so prominent in the Rocky Mountain fauna, appear to have been entirely absent; their advent during the later part of the Miocene may have been one of the main causes of the disappearance of so many of the Florissant genera, though the competition of the Tachinids must also have been important. We get here a glimpse of the drama of insect life; the development of a series of types occupying a definite place in the scheme of nature, and their replacement by other more vigorous or aggressive forms, coming from some remote region of the world. Another astonishing Florissant fossil, discovered by Mr. S. A. Rohwer, is a species of Nemopteridæ, those remarkable insects with long narrow hind wings, expanded at the end. I could not separate the species from the Old World genus *Halter;* but Navas, after examining my type, concluded that a distinct genus was indicated. He accordingly named it after Pere Marquette, and the insect becomes *Marquettia americana* (Ckll.)

Professor Wickham, who has occupied himself with the Florissant Coleoptera for several years, is now able to enumerate nearly 570 species; his latest paper, on the Elateridæ, records 43 members of that family, as against 23 species described from all other deposits of the world combined. The beetle fauna has an entirely Holarctic facies, though extinct genera are fairly numerous. The Rhynchophora are extraordinarily numerous; very much more so than in the Miocene of Europe. On the other hand, the Chrysomelidæ are relatively scarce, and there are no Histeridæ or Cicindelidæ. Among the causes which have led to the contraction of the Rocky Mountain weevil-fauna since the Miocene, must evidently be the great reduction in the number of genera of woody plants; the total

elimination of the figs, magnolias, chestnuts, elms, *Ailanthus*, and various other kinds of trees. This change in the vegetation would necessarily affect thousands of plant-feeding insects, while the climatic changes giving rise to it would favor the increase of many genera. Thus, the more we study the Miocene insects of Colorado in comparison with those of today, the more evident it becomes that the differences observed are due, not so much to any definite forward evolution, as to migrations and the extinction of a certain number of genera. It is a very striking fact, however, that in particular groups, such as Aphididæ and Bombyliidæ, the genera are practically or quite all extinct, while in others they are little different from those now inhabiting North America. The most conspicuous contrast between Florissant and the Baltic amber is seen in the bees. All the amber bees are of extinct genera; but of the 28 species of Florissant bees, only eight belong to extinct genera. Wheeler has recorded evidence that as far back as the Baltic amber, perhaps a couple of million years, the ants had many of the specialized habits they have today. Similarly at Florissant, we find that various kinds of gall-insects made galls as they do now, and leaf-cutting bees cut leaves in exactly the same manner.* Species of *Ficus*, both leaves and fruit, have been uncovered; and also a genuine fig-insect, which doubtless brought about fertilization as fig-insects do today.

From Florissant times up to the Pleistocene, we have no knowledge of the character of the North American insect-fauna. From the Pleistocene, however, a fairly large assemblage of beetles is known, and there is every reason to suppose that it will be greatly increased when more systematic search is made. The latest discovery of Post-tertiary beetles has been made in Florida; some specimens which reached me from Dr. E. H. Sellards the other day have been forwarded to Professor Wickham, who will report upon them.

The study of fossil insects adds another dimension, as it were, to the edifice of entomological science, and throws light on the broad problems of evolution. When insect remains in the

*Berry, in his excellent work on the Lower Eocene Floras of S. E. North America, recently published by the U. S. Geological Survey, figures a leaf of *Icacorea* showing numerous holes, and remarks that may indicate the work of a species of Megachilidae. The work is, however, entirely different from that of the leaf-cutting bees, and it would be a mechanical impossibility for any one of them to riddle a leaf in the manner shown.

rocks appeared to be few and scattered, the lessons to be learned from palæoentomology could not be clearly perceived. Today the situation is very different, and evidently our present knowledge of the subject is small compared with that which the next generation will possess. Not only are new localities being discovered every year, but the old ones are for the most part, at least, still as fertile as ever. There already exist in museums many hundred, perhaps thousands, of species of fossil insects which await description; many collected years ago, and strangely neglected. Entomologists certainly have the excuse that they have been more than busy with the existing insects, and with economic problems; but one might have expected that the greatest and most progressive nations would have produced a fair succession of students of fossil forms. England, until now, has neglected the splendid Gurnet Bay collections preserved in the British Museum; in America the Florissant beds were long unworked, and there are still museums where Florissant insects are preserved, without any steps being taken to get them described. In Germany, the revival of active interest in the amber fauna is comparatively recent, and on visiting the famous Oeningen deposit a few years ago, I found it had been neglected since the time of Heer. At Zurich, where Heer's types, and many undescribed species which he did not live to publish, are carefully preserved, there is no one to continue the work. Handlirsch in Vienna has produced his great work on Fossil Insects, which enormously facilitates the labors of all who are interested in the subject, and there is indeed much evidence of a new birth of palæoentomology; but many more collectors and students are needed.

Not only this, but for the development of what we may call the philosophy of entomology, of that historical perspective without which the most elaborate monographs are seriously inadequate, it is necessary that the ordinary working entomologist should take account of the fossil members of his group. It is truly extraordinary that when Scudder published his great monograph on the Tertiary Insects of North America, hardly any attention was paid to it, and for many years there was practically no one to give it, or any part of it, the serious and critical study it deserved. The organization of biological and entomological knowledge is rapidly advancing in these

days of increasing scientific activity. We like to believe that we live in the Age of Science; but there are many more lunatics than scientific investigators in the country. When science really comes to its own, when the spirit of science permeates the community, there can be no doubt that the whole face of our civilization will be changed. If, however, the material advance due to science is unaccompanied by a corresponding moral elevation; if scientific discovery merely sharpens the edge of the weapons of discord, the disruptive forces in society, it can only hasten the collapse of human civilization. Thus we understand why, in the warring countries of Europe, every effort is made to keep alive the sacred flame in the temples of pure science. Academies meet, journals are published, researches are continued, not from any indifference to the events going on around, but to preserve, so far as may be, the habit of mind which rises above the dust of conflict, and looks toward the future of mankind.

If Europe can do this in war, how much more should America in peace; unless, indeed, we are obliged to confess ourselves relatively incapable of the larger vision. The Republic of Science is the greatest of all republics, and those conscious of having a part in the common task of the world cannot cease to co-operate, even in times of war. Thus, in a large sense, philosophical entomology, entomology which recognizes the entire scope and purpose of our science, is the most serviceable, the most truly economic, of all. It ceases to be mere science, and blending with those deeper feelings which we call religion, transforms our whole point of view.

APPENDIX.

HYMENOPTERA.

Protofoenus new genus (Evaniidæ).

Antennæ long, filiform; head broad, eyes rather small; mandibles strongly incurved and sharp apically, apparently quite simple; legs slender, hind tibiæ long and slender, not at all clavate; abdomen of female thick and rather short, with a rather long very slender ovipositor directed obliquely upward; wings ample, venation of anterior pair nearly as in *Foenus*, with the same kind of first discoidal cell, in the same position, but the apical side of submedian cell oblique, not bent in middle, and the basal side of second discoidal as shown in figure. The second antennal joint is distinctly modified, broadly pyriform. The scutellum is elevated, rounded in lateral profile.

Protofoenus swinhoei n. sp. (Fig. 1, A, anterior wing; B, abdomen; C, hind leg; D, head; E, base of antenna; F, mandibles).

Length about 4.6 mm.; wings translucent, the apical half suffusedly dusky, stigma and nervures fuscous; antennæ, face and front black, but the broad cheeks entirely honey-color; thorax and abdomen black; legs mainly dark, but hind femora pallid except at base, and hind tibiæ except at apex; the minute claws appear to be quite simple.

In Burmese amber; received from Mr. R. C. J. Swinhoe.

This remarkable little insect caused me much perplexity. It seemed to resemble the Braconidæ, but it was seen to possess a very well developed costal cell. From a sketch of the venation, omitting the characteristic first discoidal cell, which I had not at first clearly seen, Messrs. Rohwer and Gahan were positive that it could not be a Braconid, and suggested affinity with the Proctotrypidæ. On further study, viewing the specimen at different angles and in different lights, I was able to make out all the characters which placed it positively in the Evaniidæ, nearest to *Foenus*, from which it differs in the shape of the abdomen and form of the hind legs. It is a primitive type related to *Foenus*, possibly the ancestral form of that genus, although on superficial examination one would not suspect the relationship.

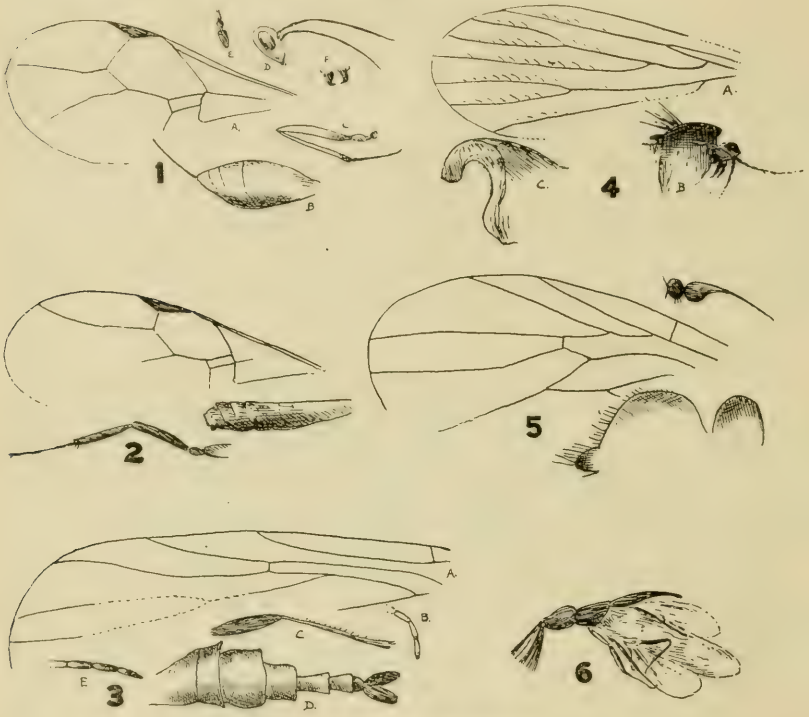
Hyptiogastrites new genus (Evaniidæ).

Related to *Hyptiogaster* but still more primitive; marginal cell truncate at base; first discoidal small, not produced apically; head much broader than thorax; antennæ long, filiform, apparently as in *Evania;* male abdomen cylindrical; legs of moderate length; claws small; hind tibiæ thickened, tarsi long, the hind femora, tibiæ and tarsi subequal; hind spurs short.

Hyptiogastrites electrinus n. sp. (Fig. 2, anterior wing, abdomen and hind leg).

Male. Length about 2.5 mm.; black, the legs and antennæ dark fuscous; cheeks black; wings perfectly hyaline, stigma fuscous, nervures light brownish.

In Burmese amber; received from Mr. R. C. J. Swinhoe.



EXPLANATION OF FIGURES

Fig. 1. *Protofoenus swinhoei* Ckll.
Fig. 2. *Hyptiogastrites electrinus* Ckll.
Fig. 3. *Sciara burmitina* Ckll.
Fig. 4. *Trichomyia swinhoei* Ckll.
Fig. 5. *Electrocyrtoma burmanica* Ckll.
Fig. 6. *Myodites burmiticus* Ckll.

DIPTERA.

Sciara burmitina n. sp. (Mycetophilidæ).

(Fig. 3, A, wing; B, palpus; C, leg; D, abdomen; E, end of antenna).

Male. Length 4.4 mm.; black, the legs brownish; palpi slender, last three joints subequal; antennæ thick, tapering and slender apically, the middle joints longer than broad, the apical ones slender, much as in *S. sendelina* Meunier; thorax very convex in lateral profile, the dorsulum forming half a circle; wings hyaline, apparently slightly dusky, with dark veins, subcosta entire; legs very long; femora thick; tibiæ very

long and slender, with minute short hairs; hind coxæ longer than head; abdomen elongated.

The wings are crumpled, so that it is impossible to get exact measurements, and the figure given, though approximately correct, must be regarded as diagrammatic. The complete subcosta is an archaic character, and might suggest a distinct genus, but the living *S. lugens* Johannsen, as figured, is not very different.

In Burmese amber (Burmite); received from Mr. R. C. J. Swinhoe.

Trichomyia swinhoei n. sp. (Psychodidæ).

(Fig. 4, A, wing; B, head and thorax; C, end of abdomen).

Male. Length about 1600 microns, wing about 1410 microns long and 560 broad. Dark brown or black, the wings clear hyaline. Antennæ long and slender, apparently 16-jointed, the joints beyond the second long and slender, hairy; palpi of moderate length; legs slender; wings with marginal fringes, and long hairs on the veins, venation as shown in figure. The thorax, in lateral profile, is produced anteriorly above, angular; the scutellum is prominent. Unfortunately the anal field of the wings cannot be seen, but the insect certainly appears to belong to *Trichomyia*, not to *Sycorax*.

In Burmese amber, received from Mr. R. C. J. Swinhoe. It is in the same piece of amber as *Sciara burmitina*. The genus *Trichomyia* appears to be on the wane. Meunier describes no less than eight species from Baltic amber (Oligocene), but Brunetti does not report the genus at all in his account of the Psychodidæ of India. In North America we have only a single species listed in Aldrich's catalogue, and that is Mexican.

Anthomyia (s. lat.) **laminarum** n. sp. (Anthomyiidæ).

Female. Length 6 mm., thickset (form nearly as in *Spilogaster*), black; wings about 4 mm. long, broad, hyaline, costa with short black bristles, costal margin conspicuously elevated and convex before end of auxiliary vein; head shaped (in lateral profile) much as in Williston, N. Am. Diptera, 3rd edition, p. 335, fig. 27, the top of head broad, and with only very delicate bristles, though the front has conspicuous bristles; dorsum of thorax, anterior to wings, with no long bristles, but there are long bristles at level of wings, the whole arrangement here apparently as in *Lispa;* abdomen stout, bristly, with a distinct short ovipositor; the depth of abdomen (doubtless increased by pressure) is 2.3 mm. The venation is much as in Williston's figure of *Choristoma*. Auxiliary vein complete, but pale; first vein ending soon after auxiliary (a deceptive appearance of its continuing parallel with the margin is due to the lower edge of the thick costa); anterior cross-vein about middle of discal cell, being 1040 microns from apex and about 1024 from base; first posterior cell not contracted at apex; width (depth) of submarginal and first posterior cells at vertical level of end of second vein each about 432 microns; superior apical angle of discal cell practically a right angle; apex of third posterior cell (angle between fifth vein and lower margin of wing) very acute.

Wilson Ranch, Miocene shales of Florissant, Colorado (Wickham). Readily known from the two previously described Florissant Anthomyiids by the anterior cross-vein being practically at the middle of the discal cell. These fossils cannot be definitely referred to modern genera, many of the essential characters being invisible. There is no doubt that the present insect is generically distinct from the other two, as genera in this family are now understood.

Electrocyrtoma new genus (Empididæ).

Minute flies resembling the modern genus *Cyrtoma* Meigen, but the rather large antennæ have a long terminal bristle; hind tibiæ and basitarsi not at all thickened; abdomen short, not extending much beyond hind femora; no detached vein in middle of wing below fourth; a considerable interval between separation of third vein from second and anterior cross-vein. Thorax greatly elevated, finely hairy; scutellum prominent, hairy; humeral cross-vein straight (not oblique); discal cell entirely open, but a slight bend in fourth vein at a point where apex of cell probably existed in an ancestor; end of anal cell and of second basal nearly in the same line; legs long and slender, but anterior femora thickened basally, the base about twice as broad as the apex.

Electrocyrtoma burmanica n. sp.

(Fig. 5, wing, antenna and dorsal profile of head and thorax).

Male. Black, with perfectly clear wings; length about 1280 microns. The following measurements are in microns: length of antennæ, 256; width of anterior femora near base, 80; length of anterior tibiæ, 352; length of abdomen (approx.) 640; length of hind femora, 464; of hind tibiæ, 416; of hind basitarsi, 208; of wing (approx.), 1040.

In Burmese amber, received from Mr. R. C. J. Swinhoe.

The loss of the outer side of the discal cell in the Empididæ appears to be a specialization. It is surprising to find in Burmese amber, the fauna of which seems on the whole to possess rather primitive characters, an insect more specialized than the ordinary Empididæ of modern times.

There is no affinity with any of the species described from Baltic amber.

COLEOPTERA.

Myodites burmiticus n. sp. (Rhipiphoridæ). (Fig. 6).

Length about 3.5 mm.; head, antennæ, prothorax and elytra black, but thorax behind level of elytra and dorsum of abdomen (except toward apex) pallid, probably ferruginous; antennæ flabellate, with at least five or six long processes; elytra short, scarcely reaching beyond base of abdomen; wings ample, hyaline, the costa pale ferruginous; legs slender, ordinary.

In Burmese amber (Burmite), received from Mr. R. C. J. Swinhoe.

I cannot distinguish this from the modern genus *Myodites*, but it is so placed in the amber that it is impossible to get a good view of the details of structure under the microscope. A species of *Myodites* has been recorded from the Oligocene of Rott, in Germany. The fossil seems to belong to *Myodites* rather than to *Emenadia*, which occurs today in the India region.

CAMPTOPELTA, A NEW GENUS OF STRATIOMYIDÆ.

S. W. Williston.

During a vacation the past season in New Mexico I found relief from monotony and much pleasure in renewing my acquaintance with the Diptera, a study to which I have given many years of my life, but which, perforce, has been interrupted during the past eight years. During the months of April and May I collected, almost daily, in the vicinity of Socorro for my friend, Dr. Aldrich. The collecting region was, for the most part, on the mesa near the foot of Mt. Socorro, and occasionally along the "bosque" of the Rio Grande. The mesa is a dry upland plain, with an altitude of about five thousand feet, covered with mesquite, with numerous dry arroyas traversing it and leading into the mountains. As would be suspected, its dipterous fauna consists chiefly of bombyliids and asilids, with some dexiids and mydaids. Of the first of these families I collected nearly forty species, and saw others that I did not have the opportunity to capture. Syrphids, empids and dolicopodids were few in number, as were the nematocerous flies, with the exception of the Culicidæ, which, after the summer rains, occur in extraordinary numbers. Most of my specimens came from the dry arroyas, very few indeed from the level plains.

The only stratiomyid I saw during the season was a single specimen of a small species that I referred in the field to an unknown genus. I searched for it afterward without success. Rather curiously I took at the same time and place two specimens of *Epacmus willistoni* O. S. that I never saw afterward.

On a recent visit to Dr. Aldrich at La Fayette, my interest in the stratiomyid was renewed. I can find no account of it in recent literature, and venture to describe it as having some features of peculiar interest.

Camptopelta, genus new.

Female. Bare. Front smooth, broad, convex, not narrowed above. Ocelli equidistant. Antennæ situated below middle of head, short. First two joints short, the second broader than long; third joint (flagellum) oval, composed of six segments; first segment longest, a little

shorter than the next two together; fourth segment tapering to the slender style; style slender, about as long as the third and fourth segments together; fifth, or basal segment of style, minute, about as broad as long; sixth segment three or four times as long as the fifth, tapering to an obtuse point and ending in a short, slender hair. Face below the antennæ a little shorter than the first six segments of the antennæ combined; nearly straight, directed downward and forward, somewhat compressed at tip from side to side. Cheeks and posterior orbits of nearly equal width, only moderately broad. Eyes bare, subcircular. Scutellum strongly convex, somewhat thinned, but not furrowed before its margin; unarmed. Abdomen smooth, convex, tapering from the broad second segment; fourth segment but little more than twice as broad as long; seventh segment minutely visible at the end of the ovipositor. Wings with veins complete; four posterior veins, the fourth separated from discal cell by a distinct crossvein; the second vein arises about opposite the proximal end of the discal cell, and a little before the short anterior cross-vein; no anterior branch to the third vein; anal cell rather broad, terminating some distance before the wing margin, the sixth vein convex. Legs simple.

Camptopelta aldrichi, species new.

Female. Shining black, bare. A large, light yellow spot on each side of the front below, narrowly separated, their upper borders in the same straight line, extending down along the orbits to about the middle of the face, convex on their inner sides. Antennæ black. Cheeks black below the eyes. Orbits on the inferior half light yellow. A light yellow stripe from the humeri to the root of the wings. The narrow lateral margin of the first three abdominal segments yellow. Legs yellow, the femora broadly black; knees and tarsi light yellow, the tibiæ in the middle more luteous or brownish. Wings pure hyaline, the veins light-colored. Length 4–5 mm.

One specimen, near Mt. Socorro, New Mexico.

The position of the genus is a little doubtful. The minute seventh segment of the abdomen, together with the scutellum and neuration will at once separate the form from the Beridinæ. From the known Pachygastrinæ (not Pachygasterinæ, as Enderlein and Malloch spell it—gasteric, gasteritis!) it differs in the neuration; from the Clitellarinæ by the origin of the fourth posterior vein; from the Geosarginæ by the absence of a distinct arista. Upon the whole its position seems to be among the Stratiomyinæ, some forms of which, at least, have the second vein arising before the cross vein. From the known American genera it will be distinguished by the unarmed scutellum and the absence of the branch of the third vein.

However, it is a question how much reliance can be placed in this family upon the absence of this branch. This vein is disappearing in this family, and it is a well known fact that disappearing organs are more or less inconstant in the individual, just as the wisdom teeth often are not erupted in the human individual. In *Odontomyia*, *Oxycera*, and other genera of the family its presence or absence is disregarded as a generic or even specific character; I am very skeptical of any genus that is based upon its absence exclusively, and that seems to be the condition in some of the more recently described genera of the Pachygastrinæ. So also, the origin of the fourth vein is not absolutely fixed in all genera.

In the latter part of May I found a species of *Geron* (Bombyliidæ) very abundant on several kinds of flowers in the canons of Mt. Socorro, and a little ways out on the plains. I could have collected hundreds of specimens had I chosen. I did capture enough, however, to show that about one in every twenty had a perfectly formed third submarginal cell. I could discover no other constant differences. Whence it follows that, in the definition of this and some other genera of the Bombyliidæ, as in several genera of the Stratiomyidæ, the number of submarginal cells does not have even a specific value. This species of *Geron* is a "sport" or "mutation" that has not yet been fixed by heredity, a developing character, apparently. *Rhabdopselaphus* Bigot was based upon a difference of the third antennal joint (*Geron trochilides* W. probably belongs with it) and with "submarginalibus tribus" cells. One of its type specimens in Mr. Verrall's cabinet has but two submarginal cells, but it is not at all sure that this genus also is not variable, and that Bigot made a mistake in his description.

Mr. Malloch, though he has never seen a specimen of *Lophoteles*, has expressed a doubt of the correctness of my generic determination of *L. pallidipennis* W.* Perhaps it is presumption on my part, in view of Mr. Malloch's knowledge of the family, to adhere to my opinion. Indeed, I long had a suspicion that not only was my species congeneric with Loew's type but that both species were identical! And this suspicion has been increased by Enderlein's discovery† of *L. plumula* Loew in Costa Rica! About the only difference he finds

*Annals Ent. Soc. Amr. 1915, p. 335.
†Zool. Anz. 1914, p. 311.

between the two is the lighter color of the knees. I may add that the figures made by v. d. Wulp for the Biologia, although himself an eminent dipterist, were not always strictly accurate in details, and it may be the differences Enderlein points out do not really exist, and that *L. pallidipennis* Williston is in reality a synonym of *L. plumula* Loew. I fear that Mr. Malloch overlooked Enderlein's paper, or he would also have discovered that his genus *Eucynipimorpha* is a synonym of *Psephiocera* Enderlein.

THE WING VENATION OF THE CERCOPIDÆ.*

Z. P. Metcalf.

INTRODUCTION.

The present paper is the third and last of a series of papers on the wing venation of the Homoptera by the writer. The other papers have been published in the Annals of The Entomological Society of America, Volume VI (Metcalf 1913a and 1913b). These two papers together with one by Funkhouser (1913), one by Miss Patch (1909) and the present paper complete the studies of the wing venation of the families of the Order Homoptera, Comstock and Needham (1898–1899) having discussed the wing venation of the Cicadidæ in their original paper on the wings of insects.

In my studies of the wing venation of the Cercopidæ I have used about the same technique that was used in studying the wing venation of the Jassidæ and Fulgoridæ. That is, the nymphal wing pads were removed from specimens that had been killed in weak formaldehyde and mounted on a slide under a cover glass. These preparations were drawn by the aid of the Edinger drawing apparatus, various combinations of objective and oculars being used. Afterwards these drawings were carefully compared with fresh mounts of wings from other specimens and if it was found to be incorrect in anyway the original drawing was discarded and a new drawing made. As noted below, material was limited in certain genera but it is believed that most errors have been eliminated.

The adult wings from which the drawings were made were dissected out and mounted in balsam. From wings thus mounted drawings have been made by means of the Edinger drawing apparatus. The drawings of the adult wings are not intended to give a picture of the wing in any sense of the word but are supposed to show the course of the veins. No attempt has been made to represent the width of the veins, the lines drawn simply showing the main axes of the veins.

*Contributions from the Department of Zoology and Entomology of the North Carolina Agricultural College and Experiment Station No. 6.

MATERIAL.

In all, five of the six North American genera have been studied. The only genus of which I could not secure nymphal material is Philaronia Ball which, however, is quite close to certain other genera and its venational characters seem quite evident on comparing it with closely related genera. In the course of these investigations which have covered odd moments for the past eight years I have had abundant material of the following genera: Monecphora A. & S. (Tomaspis Stal), Lepyronia A. & S., Clastoptera Germ. In the genus Aphrophora Germ, I have had a fair amount of material but in the genus Philænus Stal, my material has been rather limited owing to the fact that the genus does not occur in eastern North Carolina at all and only to a very limited extent in the mountains. So that for material in this genus I have had to depend on material kindly sent me from Maine by Professor C. L. Metcalf.

THE FORE WING.

The fore wing of the Cercopidæ, at least of our North American genera, is rather thick and opaque, and the venation as a rule is not very distinct or if it is plainly visible it is broken up in fine reticulations so that the main venation is badly obscured. However, an examination of the nymphal wing pads shows a condition found among certain genera of the Cicadellidæ (Jassidæ) to which family the Cercopidæ are otherwise closely related.

In reviewing the trachea of the fore wing we find that costa is typically present in all genera studied lying as a single unbranched trachea parallel to the costal border. In the adult wing this makes the vein that thickens the costal border of the wing.

A subcostal trachea has been found in all the genera of the subfamily Aphrophorinæ. It has not been found in the single genus of the subfamily Cercopinæ that has been available for study, hence it may be presumed that it is absent in this subfamily. In the adult wings of the genera closely related to Aphrophora the subcostal vein is closely united with radius both basally and distally but throughout the center of its course it is rather widely separated from radius so that it cuts off an

oval cell that is rather characteristic of the venation of these genera. (Figs. 13, 15, 17, 19.) In Lepyronia (Figs. 5, 15) subcosta is so closely joined to the radius that a part of the branches of radius appear to belong really to subcosta. In the genus Clastoptera (Figs. 9 and 21) subcosta is free and runs from the base of the wing ending in the costal border about half way from the base to the apex of the wing.

Radius is typically three branched in the Cercopidæ. These branches represent in my opinion radius one, radius two plus three and radius four plus five. This relationship seems to be perfectly clear in Monecphora (Fig. 1) where radius one branches from the main stem and runs parallel with it for some distance and then turns toward the costal border. In the adult wing (Fig. 11) this basal part is all united in the same vein so that radius one appears as a branch of radius two plus three. In the genera closely related to Aphrophora there is a strong recurved trachea running from radius two plus three to the costal border (Figs. 3, 5, 7), this I believe represents radius one whose attachment has simply been shifted further and further distally.

No nymphs of any of these genera, however, show a typical radius one, *i. e.*, as a branch from the main stem of the radius. The adult wings of these genera also show a strong vein running from radius two plus three to the costal border.

In the genus Clastoptera (Figs. 9 and 21) there is no evidence of a radius one, unless we call certain fine branches which occur near the apical angle of the wing this trachea and consider the small dark colored cell at the apical angle, cell radius one. However, it is more likely that this represents radius two. Radius two plus three usually shows some fine lateral branches towards the tip but none of these are very constant and are not worthy of being named.

The medial trachea in all our genera that I have examined is unbranched. Thus it resembles very closely the condition that has been found in certain genera of the Jassidæ. The medial trachea lies very close to the radial trachea but the medial vein is in all of our genera closely connected with cubitus, so closely joined as to appear as a mere branch of cubitus.

In the three genera Aphrophora (Fig. 3), Lepyronia (Fig. 5) and Philænus (Fig. 7) cubitus is typically two-branched as it is in many other genera of the Homoptera that I have examined.

In Monecphora (Fig. 1), however, it breaks up into a number of fine branches toward the tip, and in Clastoptera (Fig. 9) it appears to be unbranched. The three anals are always present and the third is usually two branched. I believe that it is always two branched and that in those genera in which two branches do not show the results are due to the fact that it is quite impossible to always get the anal angle of the wing pad removed carefully. This is especially evident in our preparations of Philænus but our preparations of Monecphora have usually been good in this respect. Whether the trachea is present in this latter genus or not cannot be decided now but the forming vein is usually quite distinct in good preparations (Fig. 1).

THE HIND WING.

The hind wing of the Cercopidæ bears a striking resemblance to the hind wing of the Jassidæ. Although there are certain constant differences that are worthy of being pointed out.

Radius is typically two branched in all the genera of the Subfamily Aphrophorinæ. In the Monecphora, however, it seems to be typically three branched (Figs. 2 and 4). The first of these branches which I believe to represent radius one is very variable in its relationships. In some cases (Fig. 2) it is attached to radius two plus three and in other cases (Fig. 4) it is plainly a branch of the main stem of radius. In either case it is very weak and the only remnant of it in the adult wing (Fig. 12) is a short spur attached to radius two plus three.

Medius of the hind wing is unbranched in all of our genera thus it differs decidedly from medius of the Jassid hind wing which is typically two branched. As if to compensate for this difference cubitus is two branched in all of our genera excepting Clastoptera where it is unbranched, whereas in the Jassids cubitus is typically unbranched. The three anals are typically present. The third anal is two branched and the first anal is usually very closely related to cubitus.

SUMMARY.

The present paper homologizes the wing veins of the Cercopidæ with the veins of the other Homoptera.

The venation of the Cercopidæ is quite similar in general facies to the venation of the Jassidæ although there are constant

differences. The costal and subcostal trachea are universally present in the fore wings of the Cercopidæ, whereas they are of very irregular occurrence in the Jassidæ. In the Cercopidæ medius is usually unbranched and cubitus two branched, whereas in the Jassidæ medius as a general rule is two branched with one branch very weak and cubitus is for the most part unbranched.

In the hind wing radius is mostly two branched in the Cercopidæ just as it is in the Jassidæ. Medius, however, is unbranched in Cercopidæ but usually two branched in the Jassidæ. Cubitus is, on the other hand, usually two branched in the Cercopidæ but unbranched in the Jassidæ.

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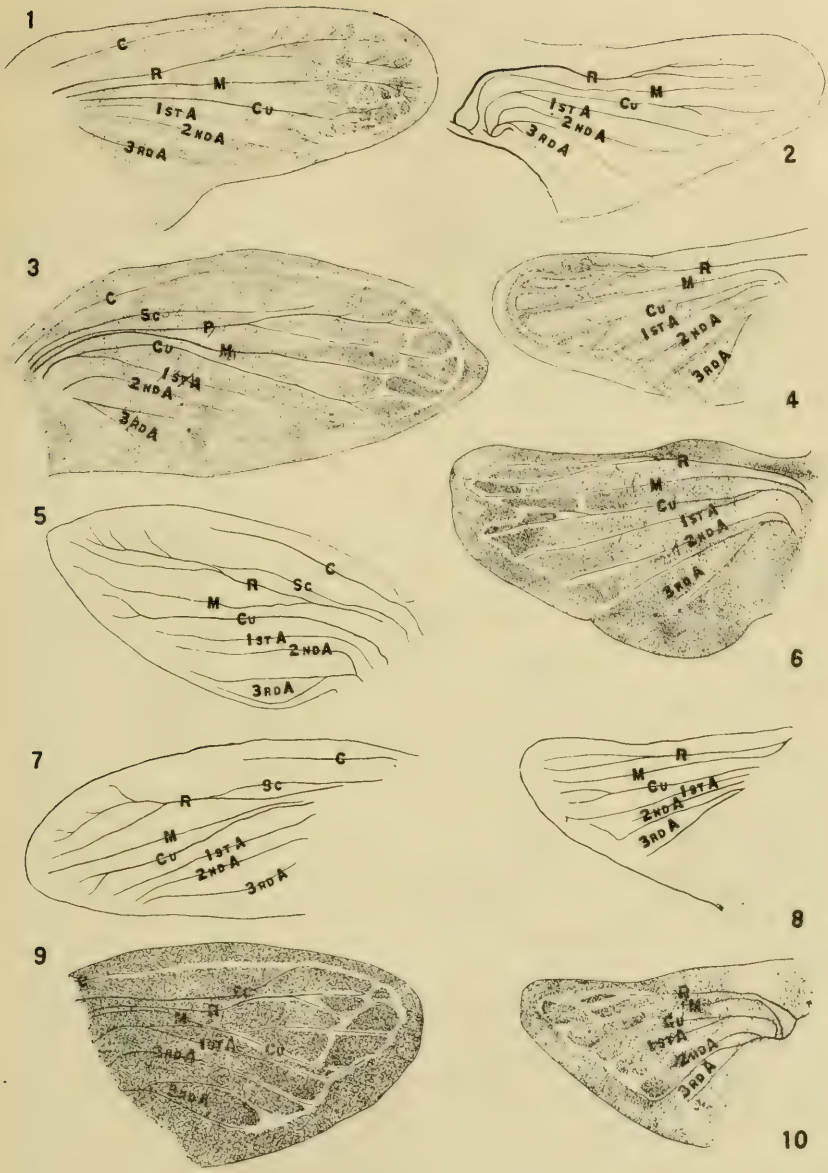
EXPLANATION OF PLATES.

Plate I.

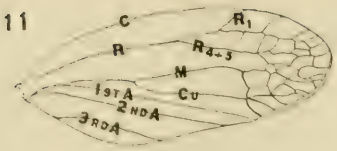
Fig. 1. Fore Wing pad of Monecphora bicincta Say.
Fig. 2. Hind Wing pad of Monecphora bicincta Say.
Fig. 3. Fore Wing pad of Aphrophora quadrinotata Say.
Fig. 4. Hind Wing pad of Monecphora bicincta Say.
Fig. 5. Fore Wing pad of Lepyronia quadrangularis Say.
Fig. 6. Hind Wing pad of Lepyronia quadrangularis Say.
Fig. 7. Fore Wing pad of Philaenus sp.
Fig. 8. Hind Wing pad of Philaenus sp.
Fig. 9. Fore Wing pad of Clastoptera sp.
Fig. 10. Hind Wing pad of Clastoptera sp.

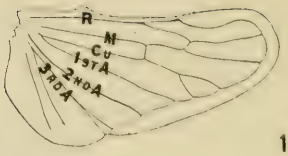
Plate II.

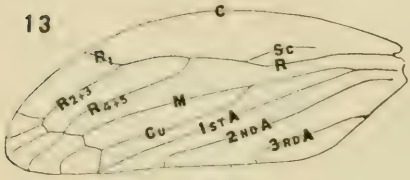
Fig. 11. Fore Wing of Monecphora bicincta Say.
Fig. 12. Hind Wing of Monecphora bicincta Say.
Fig. 13. Fore Wing of Aphrophora quadrinotata Say.
Fig. 14. Hind Wing of Aphrophora quadrinotata Say.
Fig. 15. Fore Wing of Lepyronia quadrangularis Say.
Fig. 16. Hind Wing of Lepyronia quadrangularis Say.
Fig. 17. Fore Wing of Philaenus sp.
Fig. 18. Hind Wing of Philaenus sp.
Fig. 19. Fore Wing of Philaronia sp.
Fig. 20. Hind Wing of Philaronia sp.
Fig. 21. Fore Wing of Clastoptera sp.
Fig. 22. Hind Wing of Clastoptera sp.

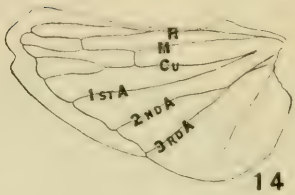

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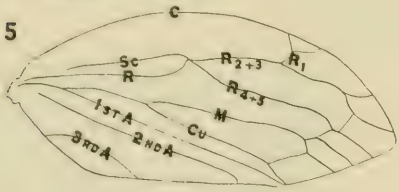
Z. P. Metcalf.

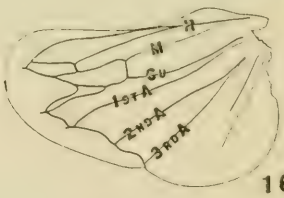

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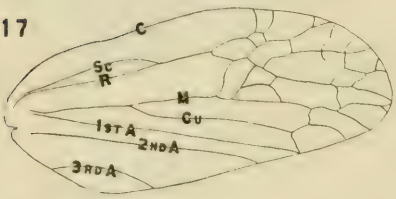

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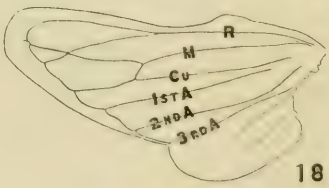

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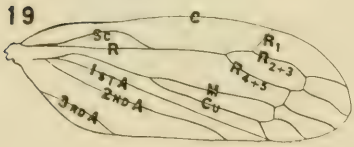

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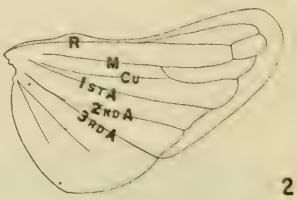

15
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R2+3
R1
R4+5
1ST A
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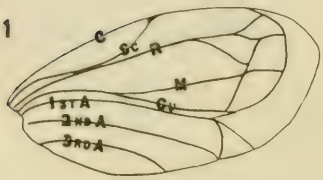

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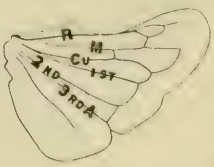

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22

Z. P. Metcalf.

FURTHER STUDIES ON HYDROMYZA CONFLUENS LOEW, (DIPTERA).*

By Paul S. Welch

INTRODUCTION

In a previous paper ('14), the writer reported the results of some observations on *Hydromyza confluens*, an aquatic dipterous insect which occurs abundantly about Douglas Lake, Northern Michigan. Parts of two seasons have since been spent in the same region and additional data, as well as confirmation of previously recorded observations, have been secured. The new material incorporated in this paper not only aids in completing our knowledge of the life history of this form but also throws new light on the interesting adaptations already described.

THE EGG

Description.—When first laid, the eggs (Figs. 1–2) are uniformly white, with a very slight tint of yellow. In clear, quiet water, they are usually more easily seen when submerged on the yellow water-lily petiole than when the latter is lifted from the water. They are elliptical in lateral view and subcylindrical (Fig. 3) in transverse section. A large number of eggs, removed from the petioles and measured, had an average length of 1.69 mm., the extremes being 1.54 and 1.76 mm. respectively. The maximum diameter, which is in a region well towards the more acute end, has an average length of 0.35 mm., the extremes being 0.30 and 0.40 mm. The ends differ distinctly in shape, one being bluntly pointed while the other is more rounded and is characterized by a depression in the apex. A straight, longitudinal, acute carina extends from end to end, occupying the mid-position in a deep, broad, longitudinal fossa, dividing it into two similar parts. This divided fossa comprises almost one-third of the periphery and is bounded laterad by two other longitudinal carinæ which extend almost parallel to the median carina, converging and uniting at the ends of the egg. The effect of this fossa is to give the egg a flat appearance on one side. Superficially, the chorion is smooth except in the region of the longitudinal fossa. The mid-longitudinal carina bears on its sides numerous minute, conical spines (Fig. 5). Similar minute projections occur on and near the vertex of each lateral, longitudinal carina. These minute processes are produced by an extra development of some of the columnar exochorionic units. The chorion is approximately uniform in thickness in all parts of

*Contribution from the University of Michigan Biological Station, No. 40, and the Entomological Laboratory, Kansas State Agricultural College, No. 20.

the egg-capsule except at the carinæ and in the depressions between them where it is distinctly thicker. The average thickness is about 0.0048 mm. The exochorion and endochorion are distinct, all variations in thickness being confined to the former which is composed in part of very minute, closely set, columnar units. For the greater part of its length, the median carina has an acute crest (Fig. 3) but near the ends it gradually merges into a lower ridge whose crest is broad and slightly rounded.

Under magnification, the surface of the chorion, except the region including the longitudinal carinæ and fossa, appears faintly but definitely reticulate, being composed of polygonal units (Fig. 4) which vary somewhat in shape and size but are usually hexagonal and more elongated in the direction of the long axis of the egg. Their average surface dimensions are about 0.112 and 0.056 mm. They contain numerous, minute, circular, uniformly distributed structures which give to the surface a granular appearance. These structures are of uniform size and appearance and are never contiguous. Structurally, they seem to be the ends of the columnar units which compose a great part of the chorion. Exclusive of the fossa and carinæ, they are present over the entire surface of the egg, being absent only on the narrow, homogeneous zones which separate the hexagonal areas.

Oviposition has not been observed and the writer has failed to secure eggs from females placed in the aquaria with food plants for that purpose. The identification of the egg has been made from a comparison with fully developed eggs dissected from females. The characteristic size, shape, and external structures, such as the carinæ, fossæ, and hexagonal areas, and a microscopical comparison of transverse sections of the eggs leave no doubt as to their identity. In addition, the writer secured a large number of eggs in various stages of development on the petioles of the water-lily and demonstrated the fact that the resulting larvæ develop the characteristic effect on the petiole, ultimately producing adults of *H. confluens*.

In connection with the dissection of females for developing eggs, it was noticed that, as in many other insects, there is a definite relation between the position of the egg in the ovariole and the shape of the completely formed egg. The larger, more pointed end is nearer the oviduct while the smaller, blunter end, which is characterized by a small terminal concavity, is nearer the terminal filament. It is then possible to determine accurately in the egg already deposited what was the previous relation to the reproductive organ.

Place and Method of Deposition.—The eggs are deposited singly at irregular intervals on the surface of the floating leaf petioles of the yellow water-lily (*Nymphæa americana* (Provancher) Miller & Standley). No eggs were found on the petioles of the submerged leaves and none were observed on other aquatic plants occurring in the vicinity of the yellow

water-lily beds. None were found on the petioles or other parts of the white water-lily (*Castalia odorata*) although both species of water-lily intermingle in the same beds. This restriction of the eggs to *N. americana* accounts for the constant relation of the larval and pupal stages to the same plant which is discussed in the earlier paper (Welch, '14, p. 136). Apparently, the female has the ability to recognize the food-plant even in the presence of numerous other aquatic plants, some of which present conditions similar to those of *N. americana* and are closely related to it.

Oviposition is constant with respect to the following features: (1) The long axis of the egg is parallel to the long axis of the petiole. (2) The surface of the egg in contact with the petiole is always opposite the carinæ and fossa. (3) The blunt end of the egg is directed towards the rootstalk and the acute end towards the leaf.

Eggs may occur anywhere from the leaf attachment to the rootstalk, even on petioles almost six feet long. As many as seventeen were found on a single petiole, scattered over a length of only one and one-half feet. An examination of a large number of petioles showed that while eggs are deposited on both the plane and convex surfaces, by far the greater number occur on the latter. The significance of this decided preference of the female in selecting the position of the egg is not known. The egg is rather firmly fixed to the surface of the petiole, apparently by a small amount of sealing fluid which accompanies the egg at oviposition. As will be shown later, the position of the egg determines the future position of the larva and pupa in the petiole.

As stated above, oviposition has not been observed and it is not known whether the eggs which occur on a single petiole are deposited by a single female or by several females. In the earlier paper, the writer ('14, pp. 138–139) called attention to the small variation in the maturity of the larvæ and pupæ and suggested that possibly the eggs on a given petiole were deposited at the same time by a single female. While this is still an open question, counter-evidence was apparently secured when, in the dissection of the ovaries of a considerable number of females, collected during the time when eggs were appearing in the field, it was found that no individual contained more than

nine approximately mature eggs at a time, the other eggs in the ovaries being distinctly undeveloped. It thus seems impossible for a female to deposit more than nine eggs during a single trip below the surface of the water, assuming that she could withstand submergence long enough to deposit the already mature or almost mature eggs, and it scarcely seems possible that the sojourn below could be so long that undeveloped eggs would have time to mature and be deposited also. Therefore, it seems improbable that, in instances where as many as seventeen eggs were found on a single petiole, all of them could have been deposited at one time by the same female. It is true, as pointed out, that the difference in the maturity among the larvæ or pupæ on a single petiole is often not marked but it may be that such a condition is due to the coincidence of the egg-laying period of a large number of females in that particular locality, a possibility which is borne out by the observation that in the region studied during the past five summers it often happened that many adjacent petioles contained larvæ of approximately the same degree of development.

Development of Eggs.—Owing to the fact that the writer was not able to secure the deposition of eggs in the laboratory, the egg period is not definitely known. Collections of eggs showing the least development were secured in the field, brought to the laboratory, kept under approximately natural conditions, and the last hatching dates recorded. This imperfect evidence points to an egg period of about six to eight days. The only noticeable external change which accompanies the development of the egg is a darkening of the color which begins to appear only a few hours before hatching.

Not only does a definite and constant relation exist in the position of the ends of the egg in the ovariole, but a similar relation exists in the orientation and development of the larva within the egg. The anterior end of the larva is invariably developed in the rounded, blunt, concave end, i. e., the one which is nearest the terminal filament while still within the ovariole. Furthermore, in all of the specimens examined, the ventral part of the larva is developed on the side opposite the carinæ and the dark, conspicuous mouth armature is curved in the same direction.

THE LARVA

Process of Hatching.—The place of emergence of the larva from the egg is a constant feature. The larva makes an exit hole through the egg capsule near the blunt, concave end, on the side next to the petiole. The position of the exit hole is determined by the position of the larva and is directly in front of the chitinous mouth armature, which, no doubt, is the instrument by means of which the opening through the shell is made. The exit hole is usually more or less circular in outline and somewhat larger than is necessary for the passage of the body of the larva. Occasionally, hatched eggs show a more extensive breaking down of the chorion next to the petiole. The larva bores directly into the petiole and there passes its entire existence. No evidence whatsoever was observed of any preliminary wandering of the larva after emergence from the egg. The latter always marks the position of the future abode of the resulting larva and pupa.

Recently Hatched Larva.—On emergence from the egg, the larva is milk-white in color, with the exception of the black mouth armature and the blackish caudal projections. The body (Fig. 6) is cylindrical, elongate, slender, and smooth. Measurements, made on living, recently hatched specimens, show a rather constant length of from 2.33 to 2.5 mm. The maximum diameter, in the region of the future thoracic segments, is approximately 0.29 mm. Intersegmental grooves are distinct but shallow. The anterior end of the body is rather bluntly rounded and shows no special structures, except the emergent teeth of the mouth armature. Posteriorly, the body is distinctly tapering and terminates in a pair of acute chitinous projections which bear the terminal spiracles. The integument is covered with very fine, pointed, conical projections. They are uniform in size and shape over the body except on the anterior margin of the first thoracic segment where they are a little more distinct. In most specimens, the translucency of the body allows the principal trunks of the tracheal system to stand out clearly. Two main, longitudinal tracheæ extend, one on each side, from the above-mentioned caudal, pointed, chitinized projections to the anterior region of the body, near the internal end of the mouth armature, where each divides into three branches. The finer details of this system have not been worked out.

Development of the Larva.—No striking external changes accompany the development of the larva. It increases in length and becomes somewhat more robust in proportion to the length. The yellowish tint in the color of the body becomes a little more apparent, the general body-surface smoother, and the intersegmental grooves less broad and deep, although they continue to be distinct. The larval period has not been accurately determined and no statement can be made at this time as to the rate of development.

The Relation to the Petiole.—Needham ('08), in describing the relation of the immature stages of *H. confluens* to the food-plant, designated the ultimate effect on the petiole as a *gall.* This same form of designation was followed by the writer ('14) in his first paper on this insect. However, subsequent work led to the investigation of the problem of whether the action of the larva on the petiole results in the production of a true gall or whether the superficial appearance of the infested petiole is merely a case of gall resemblance. Attention was called in the writer's earlier paper ('14, p. 137) to the observation that not all infested portions of the petioles showed swellings and often the diameter was not increased at all.

Specimens of the so-called galls were secured in all stages of development and sections of the same were made with the view of determining whether the growing larva produced any change in the character of the plant tissue in its immediate vicinity. An examination of these sections and a careful comparison with similar sections of the normal petiole showed that no change in the surrounding tissue occurs, that the relation of the larva to the petiole is merely one of simple interior excavation of the latter by the former and that the increase in diameter which sometimes appears is due to foreign accumulations within. The only change which was detected in the tissues was a brownish discoloration of the cells which bound the cavity made by the larva. Since the term gall is properly restricted to an abnormality in plants in which the causative factor leads to the development of tissues that differ from the normal ones, it becomes evident that the immature stage of *H. confluens* does not produce a true gall and that the occasional ovoid swelling of the petiole is not the result of an excrescence.

THE ADULT

In the writer's earlier paper ('14), a number of observations on the habits and activities of the adults were presented, and subsequent studies have yielded data which are confirmatory of the same. In addition, a few new data were secured which seem worthy of record.

Food Habits.—The relation of these flies to the yellow water-lily has been discussed somewhat in detail in the above-mentioned paper (pp. 145–147) and the possibility of nectar being produced by the flowers of *N. americana* and serving as a food for these insects was pointed out. This matter is still in doubt but the behavior of the flies in the flowers offers circumstantial evidence in favor of such a conclusion. However, it appears that the flies have other means of solving the food problem. Adults were repeatedly observed feeding on the exposed tips of the stamens. In most cases, this behavior was too long continued to be interpreted as a mere random inspection or testing of the stamen surface. The character of the food secured from the tips of stamens is not known. Possibly the pollen serves as food. Occasionally, flower stalks were, by different mechanical agents, broken off above water and partly stripped down, exposing a broken end on which an exudation of the liquid substances of the plant occurred. Flies often gathered in considerable numbers on such broken stalks and fed there for long intervals.

It also appears that these flies do not confine their feeding activities wholly to the yellow water-lily. Occasionally, adults of *Chironomus* sp. were found dead on the water-lily leaves and many of them, in the process of rapid disintegration, were discovered by these flies, the latter clustering about the dead insects and performing feeding movements. The evidence seemed conclusive that the flies were feeding on the juices of the dead insect. A number of experiments were tried by securing the bodies of *Chironomus* sp. and, after allowing them to lie in water for several hours, they were placed on the water-lily leaves where the adults of *H. confluens* were abundant. It was shown in this way that the dead insects had a distinct attraction for the flies, the latter seeking them rather quickly and definitely when not too remote from them. This response was so definite that the writer used the dead insects as a trap for the flies, thus facilitating the collection of the latter.

Light Relations.—No attempt has been made to carry on refined experiments on the behavior of these flies. However, observations and some rough field experiments were made on the relation of *H. confluens* to light, the results of which will be given in brief form.

A study of the habits of these flies in the field has shown that they are active during the day and are found in large numbers on the upper surfaces of the floating water-lily leaves. Very few were observed in any other situation. It thus appears that since the water-lilies grow in maximum exposure to sunlight and are never shaded, the flies prefer well-lighted conditions and positive phototaxis is suggested. A number of experiments were made by placing various lots of flies in a glass tube, closed at both ends and equipped with a close-fitting cover of heavy, black paper which enveloped about one-half of the length of the tube, other conditions remaining unchanged. By placing this tube in various positions with reference to the light and reversing it after certain intervals of time, the reactions of the insects could be noted. Irrespective of the position of the tube, the flies reacted positively to the light by seeking actively the uncovered end of the tube. These tests were repeated many times with the same results. The migration from one end of the tube to the other as the latter was reversed was continued over and over again without any appreciable change in the character of the response. Frequent use was made of this response in the collection of flies for other purposes and in the transference of individuals from one vial to another or from one breeding jar to another. While no experiments were carried on in order to determine whether any difference exists in the reaction by the different sexes, collections of flies from the top surfaces of the water-lily leaves, taken at random, showed no noteworthy difference in the number of males and females.

In the earlier paper, the writer ('14, p. 144) pointed out the probable method of oviposition by the female, namely, passage into the water on the under surface of the leaf and down the petiole to the places where the eggs occur. The discovery of the eggs makes this assumption all the safer. It thus appears that although the female is distinctly positive in reaction to light, this positive phototaxis is overcome by the stimuli inducing oviposition since the passage into the water is accompanied by a reduction of the light. Furthermore, the positive reaction to

light seems also to be overcome by the attraction to food since large numbers of the flies have been found on numerous occasions crowded into but slightly opened flowers of the yellow water-lily, the interiors of which were dark.

Distribution.—Attention has already been called (Welch, '14, p. 140) to the peculiar local distribution which was so marked in the Douglas Lake region. The observations of two additional seasons show that such a distribution is practically the same from year to year. Observations in other localities where *H. confluens* occurs would be of interest in this connection.

Thus far, *H. confluens* seems to have been reported only from Canada, Michigan, and New Jersey. However, there is reason to believe that it is more widely distributed than these meager data would indicate. While making a very hasty examination (June 27, 1915) of the life of the protected bays of Cedar Point, near Sandusky, Ohio, the writer found this fly, in the adult stage, in some abundance on the leaves and in the flowers of the yellow water-lily. None of the immature stages were found but this failure was due, no doubt, to the very superficial examination, lack of time preventing a thorough survey of the situation. Both sexes were present and several pairs were observed in copulation. Individuals collected at that time were bearing the pollen of the yellow water-lily and a few specimens almost completely covered with pollen were taken from the flowers. Evidently they were playing an active part in the cross pollination of these plants. Fulton ('11, p. 300) states that he found a number of flies visiting the yellow water-lilies, "*Nymphæa advena*," about Cedar Point but the particular species are not designated and his paper contains only a list of the Stratiomyidæ. Bembower ('11) studied the insect-pollinated plants of the Cedar Point region and while it was found that Diptera were collected in connection with *N. advena*, the different species are not indicated.

SUMMARY

1. Further studies on *Hydromyza confluens* in the vicinity of Douglas Lake, Michigan, confirm observations previously reported and yield new data on life history and behavior.

2. Eggs are deposited singly and irregularly along the submerged petioles of the floating leaves of the yellow water-lily (*Nymphæa americana*). Oviposition apparently does not occur on other plants.

3. The egg has certain definite and invariable external characters which facilitate identification, viz., the dissimilarity of the two ends, and the large, longitudinal fossa divided by the longitudinal carina.

4. Certain constant features with respect to the orientation and oviposition were noted: (a) In the ovariole, the blunt, concave end of the developing egg is nearest the terminal filament. (b) On the petiole, the blunt end is directed towards the root-stalk. (c) The long axis is parallel to the long axis of the petiole. (d) The side of the egg opposite the fossa and carina is in contact with the petiole. (e) The anterior end of the larva is developed in the blunt, concave end of the egg. (f) The ventral part of the larva appears to invariably develop on the side opposite the carina.

5. Incomplete evidence indicates that the occurrence of more than 7–9 eggs on a single petiole is due to oviposition by two or more females.

6. The position of the egg invariably marks the future position of the so-called "gall."

7. Microscopic examination of infested portions of the petioles shows that a true gall is not formed, the result being due to mere interior excavation.

8. In addition to the possible production of nectar by *N. americana* and its use as food, the adults were observed feeding: (a) on the exposed tips of stamens, possibly consuming the pollen; (b) on the exudation of broken, emergent flower stalks; and (c) on the dead bodies of certain insects (*Chironomus* sp.).

9. Field observations and experiments indicate that the adults exhibit a distinct, positive reaction to sunlight. It appears, however, that this positive phototaxis is overcome by the stimuli inducing oviposition and by the stimuli inducing the search for food.

10. Adults of *H. confluens* were collected about the yellow water-lily beds at Cedar Point, near Sandusky, Ohio, and evidence pointed to them as active agents in the cross pollination of these plants in that locality.

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EXPLANATION OF PLATE III

Fig. 1. Outline of egg showing surface which bears fossa and carinæ.

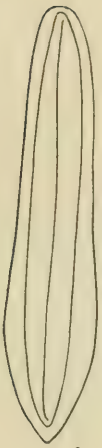
Fig. 2. Outline of egg showing shape when viewed ninety degrees from position indicated in Fig. 1.

Fig. 3. Egg capsule as it appears in transverse section.

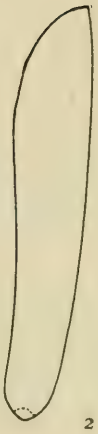
Fig. 4. Camera lucida drawing of reticulation which appears on surface of egg capsule.

Fig. 5. Transverse section of median carina of egg.

Fig. 6. Recently hatched larva.



1



2



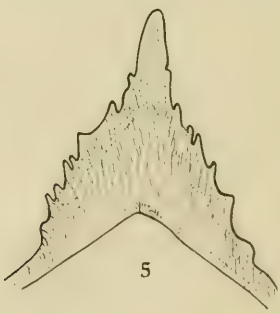
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P. S. Welch.

STUDIES ON COCCOBACILLUS ACRIDIORUM D'HERELLE, AND ON CERTAIN INTESTINAL ORGANISMS OF LOCUSTS.

By E. Melville DuPorte and J. Vanderleck,
Macdonald College (McGill University).

PART I. EXPERIMENTS ON THE CONTROL OF LOCUSTS BY THE USE OF COCCOBACILLUS ACRIDIORUM D'H.

A. Historical Resume.

Coccobacillus acridiorum, the causal organism of an epizootic disease of locusts, was isolated in the State of Yucatan, Mexico, in 1910, by Dr. F. d'Herelle from the South American migratory locust *Schistocerca americana* Drury. He had observed that during the previous year the swarms migrating northward into Mexico from the confines of Guatemala showed evidence of the presence of an epizootic. The mortality in the swarms increased each year until 1912, when the disease had destroyed the locusts to such an extent that no swarms migrated into Mexico. D'Herelle was able to produce disease and death by inoculating healthy locusts with a culture of the organism which he isolated from the diseased locusts. The results of his experiments led him to believe that the use of this organism would have successful results in the control of locusts.

In 1911–12 he was given an opportunity to test the effectiveness of his cultures against *Schistocerca paranensis* Burm. in the province of Santa Fe, Argentina, where his attempts met with a decided success.

Results obtained by Sergent and Lheritier in Algeria during 1913 were not conclusive. They found that *Dociostaurus maroccanus* Thunberg was susceptible to the disease, but the epizootic did not spread with sufficient rapidity to cause appreciable diminution in the size of the swarms. They attributed their failure to three contingencies, either the infection did not spread through the greater portion of the migrating swarm, or many of the locusts possessed a natural immunity, or else they easily acquired an active immunity against the organism.

Lounsbury in 1913 conducted experiments in South Africa to determine whether *C. acridiorum* could be effectively used in combating the non-migratory *Zonocerus elegans*. His exper-

iments were unsuccessful as the disease did not spread in the field, and he came to the conclusion that under South African conditions the biological method of d'Herelle can be used only as a supplementary measure and cannot supersede the use of poison baits in the control of locusts.

Oedaleus nigrofasciatus De Geer and *Locusta migratoroides* R. and F., two injurious locusts in the Philippines, were experimented on by Barber and Jones in 1913. An absolute failure in the field experiments was reported.

The Entomological Branch of Canada attempted without success to introduce the disease in parts of Quebec during the seasons of 1913 and 1914. Owing to the fact that the culture had to be sent a considerable distance from the laboratory in which it was prepared, which would probably affect the virulence of the organism, no definite conclusions were reached.

In 1914–15 Beguet, Musso and Sergent conducted a campaign in Algeria against an invasion of *Schistocerca peregrina* Ol. using both the biological and the mechanical methods of control. The combination of the two methods proved very successful. The biological method could not be used to protect fields that were directly menaced as the disease spread slowly. In the Sebdou region two indigenous coccabacilli were found which immunized the locusts against d'Herelle's organism. Similar organisms were reported from Algiers.

During 1915 a locust invasion of Tunisia threatened disaster over about 36,000 square miles of territory. D'Herelle succeeded in completely controlling the outbreak by means of a combination of the biological and mechanical methods.

In Morocco during 1915 Velu and Bouin conducted extensive experiments on the control of *S. peregrina*. They concluded that "d'Herelle's method gives encouraging results. Starting with a sufficiently virulent culture of the coccobacillus it is possible to create, either by spraying with bouillon or by contamination from diseased nymphs, an epizootic which is very contagious and sometimes extremely deadly, but the progress of which is by no means overwhelming." They advise its judicious combination with other methods.

The experiments described below were conducted at the request of Dr. C. Gordon Hewitt, Dominion Entomologist, during the summer of 1916. The original culture used was obtained by Dr. Hewitt from the Pasteur Institute at Paris.

B. Symptoms of the Disease.

The time elapsing between infection and the manifestation of the symptoms characteristic of the disease depends on the virulence of the organism, and may vary from a few hours to several days. Diseased locusts become sluggish and more or less paralyzed, losing to some extent the power of leaping. The excrement is black and fluid, and when the insect is dissected it is found that the contents of the digestive tract are black and more or less slimy. After death putrefaction proceeds rapidly and the integument becomes blackened.

Bacteriological or microscopical examination reveals the presence of the coccobacillus in the intestinal tract, the blood and faeces in practically pure culture.

C. Increasing the Virulence of the Organism.

It was the experience of d'Herelle and subsequent workers that the coccobacillus when grown in artificial culture media becomes very much weakened, but that the virulence could be progressively increased by passing the organism through a succession of locusts.

In order then to obtain a culture sufficiently strong for our experiments it was necessary thus to increase the virulence. The first lot of locusts was inoculated with a suspension of the original culture. On analyzing the contents of the intestines of locusts killed by this injection we obtained a pure culture of the coccobacillus. We decided then to use a suspension of the intestinal contents of the dead locusts in our further injections. Parallel with this we ran what we termed "a pure culture series," that is, a series in which the intestinal contents of the dead locusts were plated out on 1% beef peptone agar, incubated at 30° C. for eighteen hours, and then from the plates a typical colony selected and this pure culture used for inoculating the next lot. By the first method we obtained a virulent culture much sooner than by the second.

Our method of procedure was as follows: The dead locust was placed for a few minutes in alcohol. Upon removal from the alcohol its body was split along the back with a sterile pair of scissors and a portion of the digestive canal severed. The cut portion was removed with sterile forceps, dropped in a test tube containing 10 cc. of sterilized water and triturated. The suspension thus obtained was used in inocluating the healthy locusts.

The locust to be inoculated was held between the thumb and forefinger of the left hand and a drop of the suspension was injected between the first and second abdominal sternites by means of a very fine hypodermic needle.

The first lot inoculated were all dead in five days, owing doubtless to the fact that a rather strong suspension of the original pure culture was used. The second, third and fourth lots did not all die, some remaining alive for upwards of twenty-three days. After the fourth inoculation no injected locusts survived.

Some of the locusts of the second, third and fourth lots which were apparently healthy after twenty-three days were killed and the intestinal contents examined, and we found that the coccobacillus was present.

The remainder of the survivors were injected with a virulent culture and all died within a few hours.

The following table shows the increase of the virulence of the organism. The first lot in the series was inoculated with Dr. d'Herelle's culture, the others were each inoculated with a suspension of the intestinal contents of the preceding lot.

TABLE I.

SHOWING THE INCREASE IN THE VIRULENCE OF *C. acridiorum*, TEMPERATURE ABOUT 85°F

Lot	No. inoculated	Time	No. dead	Time	No. dead	Time	No. dead	Time	No. dead	Time	No. dead	Time	No. dead	Last one dead
1	12	1 day	4	2 days	6	3 days	8	4 days	9	5 days	12		...	5 days
2	12	8 hrs.	2	16 hrs.	5	27 hrs.	6	2 days	7	4 days	8	5 days	9	*
3	14	20 hrs.	6	27 hrs.	7	3 days	9	3⅓ da.	10		...		...	*
4	15	22 hrs.	3	46 hrs.	4	71 hrs.	5	6 days	6		...		...	*
5	15	21 hrs.	9	23 hrs.	11	28 hrs.	14	34 hrs.	15		...		...	34 hrs.
6	20	5 hrs.	1	9 hrs.	4	21 hrs.	16	27 hrs.	20		...		...	27 hrs.
7	12	6 hrs.	1	8 hrs.	6	96 hrs.	9	10 hrs.	10	11 hrs.	12		...	11 hrs.
8	12	15 hrs.	12		...		...		...		...		...	†
9	15	5 hrs.	3	7 hrs.	5	8 hrs.	12	10 hrs.	14	11 hrs.	15		...	11 hrs.
10	15	3 hrs.	2	8 hrs.	10	10 hrs.	14	11 hrs.	15		...		...	11 hrs.
11	12	4 hrs.	1	6 hrs.	4	8 hrs.	5	10 hrs.	8	13 hrs.	10	19 hrs.	12	between 13&19hr ‡
12	14	2 hrs.	2	7 hrs.	10	9 hrs.	14		...		...		...	9 hrs.

*Did not all die.

†No observation made until 15 hours after injection.

‡No observation made between the 10th and 19th hours after inoculation. The temperature on the day this lot was inoculated fell nearly 10°F., which accounts for the longer time required for death to occur.

After the twelfth lot there was little increase in virulence.

Quite often several locusts would die within a very short while after being injected. This was probably due to a previously weakened condition of the locusts which rendered them less resistant to the septicæmic action of the coccobacillus. The intestinal contents of those which died thus early were not as virulent as those of the ones which died later. The following table brings out this point:

TABLE II.

COMPARISON BETWEEN THE VIRULENCE OF THE INTESTINAL CONTENTS OF LOCUSTS WHICH DIE VERY EARLY AND OF THOSE FROM THE SAME LOT WHICH DIE LATER.

Source of culture	No. inoculated	Time	No. dead	Time	No. dead	Time	No. dead	Remarks
Early killed locusts.....	12	3 hrs.	1	11 hrs.	2	24 hrs.	11	1 alive after 24 hours.
Later killed locusts.....	14	2 hrs.	2	7 hrs.	10	9 hrs.	14	All dead in 9 hours.

D. Insects Susceptible to the Disease.

The pathogenicity of *Coccobacillus acridiorum* was tested for all species of locusts and grasshoppers commonly occurring in large numbers in this region. These were *Melanoplus femur-rubrum*, *M. bivittatus*, *M. atlanis*, *Dissosteira carolina*, *Camnula pellucida*, *Stenobothrus curtipennis* and *Xiphidium sp.* All of these insects proved to be susceptible.

Gryllus pennsylvanicus, one of the common field crickets, also died as a result of injection with the coccobacillus, and several dead specimens of *Nemobius spp.* were found dead in the field, doubtless as a result of eating the infected bran mash.

Of insects other than the Orthoptera only two were tested, the yellow bear caterpillar (*Spilosoma virginica*) and the potato beetle (*Leptinotarsa decemlineata*) larvæ and adults. The caterpillars were all dead in less than forty-eight hours. The number of inoculated potato beetles and their grubs which died did not exceed the number dead in the check injected with distilled water, so we must conclude that this beetle was not susceptible to the disease.

Apparently the activities of the insect and other animal parasites of the diseased locusts were not affected. We were able to rear several sarcophagid flies from diseased locusts and a very large number of living Gordioidea emerged from the diseased or dead insects.

Other workers have tested the pathogenicity of *Coccobacillus acridiorum* for various other insects and have found that not all insects are susceptible to the disease.

D'Herelle found that chickens, guinea pigs and rabbits were not susceptible and that man apparently suffered no ill effects even when the cultures were carelessly handled.

E. Experiments in the Laboratory.

Experiments were performed in the laboratory in order that we might become acquainted with the nature and action of the disease before trying it out in the field. These experiments were all carried out in breeding cages which were sterilized before each experiment.

The number of animal parasites, chiefly nematodes, and Diptera, was exceedingly high, so it must be borne in mind that several of the deaths recorded in these experiments may have been due entirely to the parasite or to the fact that the resistance of the locusts was lowered owing to the weakening action of the animal parasites.

Deaths which did not occur within a week to ten days were considered doubtful because the percentage of deaths among the checks confined for so long a time was fairly high.

Experiment 1. Effect of Spraying the Insect with a Culture of Coccobacillus.

Ten locusts were sprayed thoroughly. One died at the end of thirty hours, a second in two days, a third in three days, and at the end of eight days there were only five dead. The others remained alive for some time showing no symptoms of disease.

Experiment 2. Effect of Contaminating the Soil.

a. Twelve locusts were placed in a breeding cage containing sand sprayed with a culture of *C. acridiorum*. One died at the end of the first day. The others remained alive for several days and showed no symptoms of disease.

b. Several locusts were placed in an unsterilized cage from which dead locusts had just been removed. No mortality was produced.

Experiment 3. Effect of Contaminating the Food of the Locusts.

a. Seventeen nymphs were placed in a cage containing green food sprayed with a culture of the organism. The food was renewed daily and for several days it was sprayed either with a pure culture of the coccobacillus or with a suspension of the intestines of dead locusts. There were no deaths until the fifth day, when one nymph died. After this there were a few deaths at intervals. The experiment was discontinued at the end of three weeks. The intestines of some of the living locusts were then examined and *C. acridiorum* was found.

b. Twenty locusts were fed with sweetened bran mash to which a culture of the coccobacillus had been added. Two died during the next day. By the seventh there were altogether twelve dead and on the eleventh day fifteen. The others survived for eight days after being removed to a clean cage.

Experiment 4. Infection from Dead or Diseased Locusts.

Experiments were tried to determine whether the disease would spread readily from dead or diseased locusts to healthy ones. To this end a number of healthy locusts were placed in a cage with others that had just died. The locusts used were largely *M. femur-rubrum* with a few individuals of other species. Nearly all the locusts failed to show symptoms of the disease.

It was observed that occasionally a *bivittatus* would feed on the dead insects. In order to determine the effect of this cannibalistic tendency on the spread of infection we placed *femur-rubrum* and *bivittatus* in equal numbers in a cage with dead locusts. At the end of eight days 80% *bivittatus* were dead and only 20% *femur-rubrum*. We have never in our experiments observed any manifestation of cannibalism in any of the forms of locusts and grasshoppers experimented on except *M. bivittatus*, and in this case the tendency to prey on the feeble individuals is not very marked.

Experiment 5. Relative Resistance of Male and Female Locusts.

We were unable to observe any difference in the resistance of male and female locusts. The following is an example which shows how similar the two sexes are in the degree of susceptibility:

TABLE III.

Sex	No. inoculated	NUMBER DEAD IN					
		10 hrs.	12 hrs.	14 hrs.	15 hrs.	16 hrs.	20 hrs.
Female....	10	4	5	7	8	9	10
Male.....	10	5	6	7	8	9	10

Experiment 6. Relative Resistance of Adult and Nymph.

It was observed during the various experiments that the nymphs apparently were more resistant than the adults. Two experiments to definitely prove this gave the results shown in the following table:

TABLE IV.

Stage	No.	NUMBER DEAD IN							Alive at end of 13 hrs.
		3 hrs.	6 hrs.	8 hrs.	9 hrs.	11 hrs.	12 hrs.	13 hrs.	
Adult.....	10	1	3	6	9	..	..	..	1
Nymph.....	10	..	..	1	2	3	4	5	5

TABLE V.

Stage	No.	NUMBER DEAD IN							
		10 hrs.	11 hrs.	12 hrs.	13 hrs.	14 hrs.	16 hrs.	18 hrs.	23 hrs.
Adult.....	10	2	5	9	10	..	..	..	..
Nymph.....	10	2	..	3	..	4	6	7	9

Experiment 6. Relative Susceptibility of Different Species.

Experiments were tried to ascertain whether there was any difference in the susceptibility of *M. femur-rubrum*, *M. bivittatus*, *D. carolina* and *S. curtipennis*. In no two experiments did the results accord, so we concluded that, as far as these four species are concerned, differences in susceptibility are individual rather than specific.

Similar results were obtained when we tried to ascertain whether any one species was more susceptible to a culture obtained from the same species or from a different species.

From the results of the foregoing experiments it is clear that *Coccobacillus acridiorum* is pathogenic to all the common injurious locusts and grasshoppers of Eastern Canada, and that these insects are equally susceptible. The immature stages of the insects are more resistant than the adult stage.

Infection does not spread readily to healthy insects by mere contact with diseased locusts or other contaminated material. The chief, if not the only method of spreading the disease, is by ingestion of infected material.

While many individuals are tolerant of a mild infection they are not totally immune because all the locusts which survived in the various experiments succumbed when re-inoculated with a strong virulent culture. Their tolerance is probably due to the presence of certain closely allied bacilli in the intestines.

F. Experiments in the Field.

Experiments in an Enclosed Area:

In order to be definitely certain of our results a small area of a lawn was enclosed with screen-wire and numerous locusts included in the enclosure.

Experiment 1.—The grass of the enclosed area was sprayed with a bouillon culture of *C. acridiorum* and daily observations made for a week. During this time not a single death was recorded. The failure of this attempt was probably due to the death of the organism as a result of its exposure to bright sunlight. As it remained very bright for some time after this the experiment was not repeated.

Experiment 2.—A new portion of the lawn was enclosed and sown with sweetened bran mash to which a bouillon culture of the organism had been added. On the second day we found 21 dead locusts, and several others showing symptoms of the disease. At the end of five days we had collected altogether 108 dead locusts. Many of the survivors were then placed in insect cages and the majority died within five days of their capture.

Experiment 3.—Twenty locusts inoculated with a virulent culture of *C. acridiorum* were introduced among the healthy locusts in another enclosed area. At the end of the fifth day only 39 dead locusts, including the inoculated ones, were found. The experiment was continued for several days but no further deaths were recorded.

Experiments in the Open Field:

Two unsuccessful attempts were made to create an epizootic centre in the open field.

Experiment 1. The first attempt was made in a clover field badly infested with *M. femur-rubrum*. A small area of this field was treated with the infected bran mash. The field was examined daily but comparatively few dead locusts and no evidences of an epizootic were found. Numbers of locusts were collected from this field and placed in insect cages but the disease did not develop among them.

Experiment 2. A similar experiment was conducted on a badly infested lawn with the same results.

G. Conclusions.

The results of our work indicate that d'Herelle's biological method for the control of locusts cannot take the place of the methods now in use under the conditions which obtain in Eastern Canada. Should the disease become established, its spread would be extremely slow owing to the non-migratory and non-cannibalistic habits of the native species. The ideal conditions for the effective use of this method are those such as d'Herelle and others found in South America and North Africa where the locusts were in quickly moving swarms and were markedly cannibalistic in their habits. Indeed, most of these writers have emphasized the fact that "acridiophagy" is the chief factor in the spread of the disease. Another hindrance to the effective use of this method lies in the presence of several native strains of a coccobacillus identical with or closely related to d'Herelle's. These organisms are undoubtedly responsible for the immunity of the locusts to a mild infection of *Coccobacillus acridiorum*.

PART II. DESCRIPTIVE STUDIES ON COCCOBACILLUS ACRIDIORUM D'HERELLE, AND SIXTEEN RELATED NATIVE ORGANISMS.

During the early part of our work we made plates daily from the intestinal contents of dead locusts. In every case we got a pure culture of the organism. The culture medium used was 1% beef peptone agar and the plates were kept at room temperature (about 30° C.). The growth under these conditions is rapid. The colonies are spreading and filmy and not

as sharply defined and compact as they appear in a more concentrated agar. The typical colonies appeared within ten hours and the culture was always ready for use within 18 hours.

An attempt was made to estimate the number of viable organisms found in the digestive tract of insects which had died from the disease and also of those which survived infection. As one would expect, the number of coccobacilli in the intestines of dead locusts varied between very wide limits, depending probably on the length of time elapsing between infection and death, and on the number of organisms originally injected. The number usually exceeded 100,000 and our experiments showed that this number continued to increase after the death of the host.

4 hours after inoculation, just dead, 100,000 organisms.
10 hours after inoculation, 6 hours dead, 400,000 organisms.
24 hours after inoculation, 20 hrs. dead, 5,000,000 organisms.

Locusts which survived infection gave a much lower count, as the following table shows:

TABLE VI.

NUMBER OF COCCOBACILLI IN INTESTINAL TRACT OF LOCUSTS SURVIVING INFECTION.

SOURCE OF INFECTION	NUMBER OF COCCOBACILLI
Weak culture *Coccobacillus*	150
Stronger culture *Coccobacillus*	1,600
Infected food in laboratory	1,500
Contact with dead locusts	200
Infected food in enclosed field	30,000

Viability of Coccobacillus acridiorum in Bran Mash.

If bran mash is used for the conveyance of the coccobacillus it would be important to know how long the organism will retain its virulence in the mash. To test this we placed a shallow receptacle of bran in the shade out of doors. On the first day there were 365 million coccobacilli per gram of bran mash. After four days the number was reduced to 100 million, and a few of the locusts which were fed this mash died. At the end of eight days there were 250,000 coccobacilli per gram of bran mash. Locusts injected with a pure culture of coccobacilli from the eight day old bran did not die.

Native coccobacilli isolated from the digestive tract of Locusts.

In the first part of this paper we stated that our failure was probably due in part to the immunizing effect of native strains of coccobacilli.

We have described altogether sixteen organisms, some practically identical with d'Herelle's organism, the others more or less closely related.

The first culture was obtained from an individual of *Melanoplus bivittatus* which dropped dead near one of the authors at some distance from the laboratory, before any experiments were tried in the field. This coccobacillus showed a progressive increase in virulence similar to *Coccobacillus acridiorum.*

The other cultures we obtained both from apparently healthy locusts and from diseased or dead ones. In addition to those described a few other organisms were isolated, but we have included only those which are allied to *Coccobacillus acridiorum* and which injected into the intestinal canal of locusts cause death within twenty-four hours.

TABLE VII.

SOURCE, NUMBERS, ETC., OF THE COCCOBACILLI DESCRIBED.

Culture	Source	Location	TotalNo. of organisms	Coccobacilli	Other organisms
3	M. femur rubrum (healthy)	Montreal Island	4,000	4,000	
5	D. carolina (healthy)	"	7,000	7,000	
13 & 14	M.femur-rubrum "	"	1,400	1,400	
12	" " "	"	4,400	4,400	
15	" " "	"	3,500	3,000	500
6	M. bivittatus "	"	6,800	6,750	50
10	D. carolina "	Islet in Lake St. Louis	7,000	7,000	
11	S. curtipennis "	"	840	840	
8	M.femur-rubrum "	"	560	560	a few developed later
17	" " "	Mainland	4,400	4,400	
7	D. carolina (dead)	Montreal Island	600,000	600,000	
2	M. bivittatus (dead)	"	200,000	200,000	
4	" (diseased)	"	60,000	60,000	
16	" (parasitized by maggot)	"	200	60	180

We include below d'Herelle's original description as well as a fuller description by ourselves of the culture received from the Pasteur Institute. For convenience the organisms are divided into four groups. The first group includes *C. acridiorum* and those native coccobacilli which are practically identical with it; the second and third groups include strains which differ in several details, and the fourth group includes two organisms which differ chiefly in the fact that they are able to liquefy gelatine.

Coccobacillus Acridiorum d'Herelle.

Original Description by d'Herelle.

Morphology. Short bacillus, slightly oval, polymorphous. Cocci 0.6μ, bacilli 0.4μ–0.6μ by 0.9μ–1.5μ. Very motile. Flagella peritrichiate. Stains easily. Gram negative.
Agar Stroke. Not mentioned.
Potato. Growth abundant, creamy. Condensation water, syrupy and strongly alkaline.
Gelatine Stab. Not mentioned.
Nutrient Broth. Turbidity apparent after 4 hours, no sediment, clearing after 3 weeks with slight sediment, odor of beef extract.
Milk. Coagulated, strong alkaline reaction.
Litmus Milk. Not mentioned.
Gelatine colonies. No liquefaction.
Agar colonies. Circular in shape, waxy, visible after 12 hours, 18 hours, 3 mm. diameter. *Below surface* small, spherical, whitish opaque.
Aesculin agar. Not mentioned.
Fermentation of Sugars. +glucose, levulose, galactose, maltose. No other sugars mentioned.
Indol. Not mentioned.
Neutral red bilesalt Agar. Not mentioned.
Pathogenicity. Pathogenic to various Acrididæ, ants and caterpillars.

GROUP I.

Culture of C. acridiorum from Pasteur Institute, and Cultures 6, 7, 13 and 14.

Morphology. From agar slope 20 hours old, short rods or cocci, some oval, polymorphous. 0.7μ–1.0μ. In milk culture they appear often as diplococci. Motile. Gram—. Amylgram+. Stain readily.
Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white to bluish white, opaque, butyrous, medium unchanged. On 1% agar the cultures are arborescent and transparent.
Potato. Abundant growth, spreading, flat, glistening, smooth, butyrous; color from dirty white to yellow.
Gelatine Stab. Uniform growth, line of puncture filiform. No liquefaction, medium unchanged. Stab brownish yellow.
Nutrient Broth. Pellicle or ring, turbidity, slight sediment, no clearing after 14 days, odor of beef extract.
Milk. At first gas production without coagulation. Delayed coagulation in 2–8 days, acid reaction after 8 days, no peptonisation, medium unchanged, no extrusion of whey.
Litmus Milk. Gas production, weak acidity, no reduction. After 4 days partial to complete coagulation, acid.
Gelatine Colonies. Growth slow, round, raised, edge entire, yellow. 3 weeks, 2 mm. diameter, yellow white. No liquefaction.

Agar colonies. Rapid growth, irregular, round, smooth, flat, edge entire, amorphous, dirty white to blue transparent. Growth more restricted on 1½% than on 1% agar.

Aesculin bilesalt agar. C. acridiorum weak field after 24 to 48 hrs. Cultures 6, 7 and 13 typical black field after 24 hrs., greatly increased in intensity after 48 hrs. Culture, 14, no field after 24 hrs., very intense black field after 48 hrs.

Fermentation of sugars. +glucose, galactose, muscle sugar, lactose (weak). —adonit, dulcit.

Differences are observed in the following sugars:

	C. Acrid.	Cult.6	7	13	14
Saccharose	+	+	+	+	—
Rafinose	+	+	+	+	—
Arabinose	+	—	—	+	+

Indol reaction. Negative.

Neutral red bilesalt agar. C. acridiorum strong fluorescence, red, spreading.
Culture 6, strong fluorescence, canary yellow, spreading.
Culture 7, strong fluorescence, canary yellow.
Culture 13, strong fluorescence, canary yellow, red ring, spreading.
Culture 14, strong fluorescence, canary yellow, red ring, spreading.

Pathogenicity. Pathogenic to locusts and grasshoppers. Injection fatal within 24 hours.

GROUP II.

Cultures 4, 10, 12, 20.

Morphology. From agar slope 20 hrs. old. Short rods or cocci, polymorphous. 0.7μ–1.0μ. In milk culture they appear as micrococci or diplococci. Decidedly motile. Gram—. Amylgram+, except Culture 12, which is negative. Stain easily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white to bluish white, opaque, butyrous, medium unchanged. On 1% agar the cultures are arborescent and transparent.

Potato. Growth abundant, spreading, flat, glistening, smooth, butyrous, color from dirty white to deep yellow. Culture 12 has a drier growth than the other cultures.

Gelatine Stab. Growth uniform, line of puncture filiform, of a yellow brown color, no liquefaction, medium unchanged. Culture 20 started to branch after 14 days, the stab was white in color.

Nutrient broth. Culture 4, Pellicle, turbidity, sediment, no clearing after 14 days.
Culture 10, Ring, turbidity, sediment. Clearing after 48 hrs., odor of beef extract.
Culture 12, Ring, turbidity, no sediment, no clearing, after 14 days but slight sediment.
Culture 20, Turbidity, sediment, no clearing.

Milk. Gas production without coagulation. Delayed coagulation in 3 days, except in case of Culture 10, which did not coagulate at all, acid reaction, no peptonisation, medium unchanged, no extrusion of whey.

Litmus Milk. Gas production with weak acidity, no reduction. After 4 days acid and complete coagulation except Culture 10, which remained neutral to slightly alkaline and liquid.

Gelatine colonies. Culture 4, growth moderate, brownish white, round, convex, entire, no liquefaction, size 1 mm.
Culture 10, heavy growth, bright yellow, round, convex, entire, no liquefaction, 1 mm.
Culture 12, very slow growth, white punctiform, no liquefaction.
Culture 20, slow growth, bluish white, punctiform, no liquefaction.

Agar colonies. Rapid growth, round, flat, edge entire, internal structure amorphous, blue transparent.

Aesculin agar. Culture 4, decided black field after 24 hours; very strong after 48 hours.
Culture 10, no growth 24 hours, slight growth, weak field 48 hours.
Culture 12, decided field after 24 hours, very strong after 48 hours.
Culture 20, no field after 48 hours, good growth.

Fermentation of sugars. —dulcit, raffinose.
+saccharose, glucose, lactose, muscle sugar, galactose.
Culture 10 in general causes very little fermentation, only traces in saccharose and glucose.
Differences are shown—

	4	10	12	20
Adonit	+	—	+	—
Arabinose	+	—	—	+

Indol reaction. Negative.
Neutral red bilesalt agar. Culture 4, fluorescence, canary yellow, slightly spreading.
Culture 10, slight fluorescence, canary yellow.
Culture 12, strong fluorescence, canary yellow.
Culture 20, canary yellow, red ring.
Pathogenicity. Pathogenic to locusts. Death by injection occurs within 24 hours.

GROUP III.

Cultures 2, 3, 5, 15, 16, 17.

Morphology. From agar slope 20 hrs. old. Short rods or cocci, polymorphous. 1.5μ–0.9μ. In Milk culture they appear as small or large micrococci. Very motile. Gram—. Amyl gram, cultures 2, 5, 15, 17 negative, cultures 3, 16+. Stain easily.
Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white, opaque, butyrous, medium unchanged. On 1% agar cultures are aborescent and transparent.
Potato. Cultures 2 and 17 growth abundant, spreading, flat, glistening, smooth, dry and brittle, yellow color. Cultures 3, 5, 15 and 16 abundant growth, spreading, flat, glistening, smooth, butyrous, dirty white to yellow.
Gelatine stab. Growth uniform, line of puncture filiform, of a yellow brown color, no liquefaction, medium unchanged.
Nutrient Broth. Pellicle or ring, turbidity, no clearing after 14 days, slight sediment, strong odor of beef extract.
Milk. Gas production without coagulation. Delayed coagulation except Culture 17, liquid and acid after 8 days.
Litmus Milk. Gas production with weak acidity. Cultures 5, 16 and 17 complete reduction; Cultures 2, 3, 15 no reduction. Cultures 2, 5, 16, 17 coagulation within 4 days; Cultures 3 and 15 no coagulation, acidity in Culture 3, neutral reaction in Culture 15.
Gelatine Colonies. Cultures 2, 3 and 5 slight growth, punctiform, white, no liquefaction. Cultures 15, 16 and 17 good growth, size 2 mm., bright yellow, round, convex, entire, no liquefaction.
Agar colonies. Rapid growth, round, flat, edge entire, internal structure amorphous, blue transparent, below surface small, spherical, whitish, opaque.
Aesculin agar. Culture 2 negative, Culture 15 no growth, Cultures 3, 16 and 17 positive, Culture 5 very weak.
Fermentation of sugars. +galactose.

	Adonit	Dulcit	Raffinose	Arabinose	Muscle sugar	Saccharose	Lactose	Glucose
Culture 2	—	+	—	+	+	+	+	+
Culture 3	+	+	+	+	+	—	+	?
Culture 5	—	—	—	+	—	+	+	+
Culture 15	—	—	—	—	—	+	—	?
Culture 16	—	—	?	+	+	+	+	+
Culture 17	—	?	—	+?	+	+	+	?+

Indol reaction. Cultures 2 and 3 very strong. Cultures 5, 15, 16, 17 negative.
Neutral red bilesalt agar. Cultures 2 and 3, red.
Culture 5, fluorescence, canary yellow, spreading.
Cultures 15 and 17, fluorescence, canary yellow.
Culture 16, canary yellow, red ring.
Pathogenicity. Pathogenic to locusts and grasshoppers. Death by injection within 24 hours.

GROUP IV.

Cultures 8 and 11.

This group shows much resemblance to Group III, but its ability to liquefy gelatine made it necessary to separate the two groups.

Morphology. From agar slope 20 hrs. old, short bacillus, slightly oval, polymorphous, 0.5μ–1.0μ. Very motile. Gram—. Amyl gram+. Stain easily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white, opaque, butyrous, medium unchanged. Arborescent on 1% agar.

Potato. Growth abundant, spreading, flat, dull, smooth, butyrous, white.

Gelatine Stab. Growth rapid, liquefaction along puncture, on top saucer shape after 24 hours, completely liquefied in 7 days.

Nutrient broth. Culture 8 pellicle, turbidity, sediment, strong odor of beef extract. Culture 11, ring, turbidity, strong odor of beef extract. No clearing after 14 days.

Milk. Coagulation prompt, strong acid and gas, no extrusion of whey, medium unchanged.

Litmus Milk. Acid coagulation, no reduction, slow peptonisation.

Gelatine colonies. Complete liquefaction within 24 hours.

Agar colonies. Rapid growth, round, smooth, flat, edge entire, amorphous.

Aesculin agar. Negative.

Fermentation of Sugars. Negative. —Adonit, dulcite, galactose, arabinose, muscle sugar, lactose, raffinose. Weak, saccharose, glucose.

Indol reaction. Weak.

Neutral red bilesalt agar. Strong fluorescence, canary yellow.

Pathogenicity. Pathogenic to locusts. Death occurs within 24 hours of injection.

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THE CHORDOTONAL ORGANS AND PLEURAL DISCS OF CERAMBYCID LARVAE.*

WALTER N. HESS.

INTRODUCTION.

For years systematists who have attempted the classification of certain coleopterous larvæ, have been perplexed by the peculiar and varied structures on the abdominal pleural region. These often take the form of a ray-like disc in the larger species, while in the smaller species, a small elliptical enlargement is present in this region. Many larvæ, even among the Coleoptera, do not possess the characters in question, but they seem to be universally present among the Cerambycids. Moreover, they are often much modified in the different genera.

During the summer of 1914, Dr. W. A. Riley, of this department, found these peculiar pleural structures on various larvæ. About the same time Mr. F. C. Craighead, of the Department of Entomology at Washington, wrote Dr. Riley asking about their functions. It was at this time that the writer undertook a study of their structure.

The writer is sincerely indebted to Mr. Craighead for mounts of these structures which he had turned over to Dr. Riley, also to Dr. Riley himself for much valuable advice and assistance.

In some larvæ, especially the larger species of Prionids, these structures are very pronounced, and instances have been known of students mistaking them for spiracles.

References in the literature are practically limited to a brief mention by Perris (1877). This writer spoke of them in the Cerambycids as "accessory locomotor organs." However, this interpretation was not accepted by Craighead (1915), who refers to them by the non-committal name of "pleural discs."

It will be shown in this paper that these external characters are not constant in all genera of the Cerambycids, that in spite of an external variation, the internal condition is usually constant, and finally, that the pleural discs are the points of attachment of abdominal chordotonal organs. The detailed structure of the latter will be described.

*Contribution from the Entomological Laboratory of Cornell University.

MATERIALS AND METHODS.

Although the histological investigation of this problem was limited to two species, *Ergates spiculatus* Lec. and *Monohammus confusor* Kirby, larvæ of other genera were examined to determine the presence and arrangement of the organs. Among these larvæ were specimens of *Saperda candida* Fabr., *Rhagium lineatum* Oliv., *Desmocerus palliatus* Forst., and *Mallodon dasystomus* Say.

In dissecting out the structure for toto preparations, best results were obtained by opening the larvæ on the mid dorsal line, and pinning them open in a watch crystal which had been half filled with paraffin. As a dissecting medium, picric alcohol was very satisfactory. In addition, Delafield's hæmatoxylin was frequently used to aid in differentiating the tissues for gross dissection. For mounts of the entire organ, staining with borax carmine was very satisfactory. Portions for sectioning were obtained from the fresh larvæ by cutting out the parts in each segment which contained the organs, and placing these directly into fixing fluids.

The parts for histological study were fixed in strong Flemming's solution for twenty-four hours, washed thoroughly, and dehydrated by the usual process. However, formol-chromic acid, as used by Schwabe, was found very satisfactory for fixing these organs. The material was infiltered in 54° paraffin for three hours, then in 58° paraffin for one hour, and imbedded. Sections were cut two, three, four, and five microns thick. For the study of cross sections, those cut two and three microns thick were more satisfactory, but for longitudinal sections, those cut at five microns were best, as it was very difficult to obtain thinner sections that showed the internal structures. For staining, Heidenhain's iron hæmatoxylin was found the most satisfactory.

LITERATURE.

Before taking up the description of these structures, we shall discuss briefly the more important work that has been done upon the chordotonal organs in insects. It is very probable that more has been written on these structures in the adult Orthoptera than in all the other insects together. Although many authors have described these organs in the insects of other orders, very little attention has been given to their condition in the larvæ.

According to Graber, details of the auditory organ of insects were first described by John Müller (1826). Müller discovered a structure in the tympanum of the Acrididæ, which he described as an elongated bubble filled with water, one end fastened to the tympanic membrane, the other end extending in the opposite direction.

Siebold (1844) found in the fore tibia of the Locustidæ, a ganglion-like body which ended in the form of a band at the side of a large trachea, and which was composed of rod-shaped little bodies. Some later writers attribute the discovery of the auditory nerve end-organ, or scolopophore, to this worker.

Leydig (1851) found in the larva of *Corethra plumicornis*, nerve endings which were located in the segments of the abdomen. They were attached at each end to the skin, and stretched lengthwise across the clear space located between the body wall and the muscles. In 1860 Leydig farther investigated the adults and larvæ of Diptera and Coleoptera, and demonstrated the peculiar nerve end apparatus. He described these structures in the antennæ, halteres, and wings, but did no farther work on the abdominal organs. His is the first clear description we find of these nerve end bodies, and as a result Leydig is given credit for discovering them.

Weismann (1866) found in *Corethra plumicornis*, little nerve endings which he called "cords of hearing." He maintained that this hearing cord was very suitable to be set into vibration by sound waves.

Hensen (1866) showed that in the Locustidæ, the nerve fibers of the auditory nerve join the auditory rod or scolopale. Schmidt (1875) largely confirmed the work of Hensen, but discovered that the nerve fiber extended from a basal ganglion cell into the scolopale.

Although the workers mentioned above contributed considerable to our knowledge of these sense organs, the work of Graber (1881–82) laid the foundation for all future work. This worker called chordotonal, all organs that had nerve endings similar to those of the previously described auditory rods of the Orthoptera, and maintained that such organs serve an auditory function. He supported this view by showing that chordotonal organs in the various orders of insects all contain peg-like bodies or scolopalæ, such as are found in the tympanal organs of the Orthoptera.

Graber discovered that chordotonal organs are seldom, if ever, found singly, but usually in groups of two to two hundred or more to a system. He discovered that they are located between two immovable points, usually near the body-wall, free from the movements of the inner organs.

He found them in various species of Orthoptera, Neuoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera. They were not always in the same region of the body, but rather often variously located in the different groups. He observed them in the segments of the abdomen, in the antennæ of larvæ, in the legs and tarsi, in the halteres, in fore wings and the subcostal veins of hind wings. His extended observations led him to believe that the whole integument of insects, like the tympanum of vertebrates, is especially suited to be set into vibration by sounds, and that the nervous structures united to them can react to different sound waves.

Of the larvæ in which Graber reported finding these structures were: Dytiscus among the Coleoptera; Tabanus, Chironomus, Tanypus, and Syrphus among the Diptera; and Nematus among the Hymenoptera. His descriptions of these larval structures are very suggestive of what I have found in the abdomen of the Cerambycids.

From his rather extensive study of widely separated forms, Graber concluded that these organs, though often different in shape, were all alike in essential details. He noticed that the nerve end-organ had three nuclei, but it remained for a later worker to discover the exact relation between the parts of the structure itself.

Schwabe (1906) in his work on the Locustidæ, first showed that the nerve end-organ or scolopophore is composed of three cells with definite cell boundaries. These are: a cap cell, which is often elongated and attached to the body wall; a central portion or enveloping cell; and the sense cell which bears the nerve.

Schwabe's results have been largely confirmed by Schon (1910), Vogel (1912), and Lehr (1914).

THE PLEURAL DISCS OF CERAMBYCID LARVÆ.

We have already seen that the pleural discs of cerambycid larvæ are the outward expression of chordotonal organs. Since these external structures of various larvæ are being used as systematic characters, we will consider briefly their arrangement and relation in the different genera. In many species of the Prionids, such as *Mallodon dasystomus*, we find a condition such as is shown in Fig. 1, in which there is a pair of definite ray-like structures on the pleural region of each of the first six abdominal segments. These constitute the pleural discs (pl. disc) strictly speaking. On the seventh and eighth abdominal segments they are present, though somewhat modified. Instead of a simple ray-like structure, we find here an elliptical enlargement which Craighead calls the "Pleural tubercle" (Pl. Tu.). At the posterio-dorsal side of this tubercle, the pleural disc can be faintly seen (pl. disc). This ray-like structure or pleural disc, has a small median depression, at the central point of which a chitinous cap usually projects for a short distance. From this median depression, there radiate folds in the body wall, producing the previously described ray-like appearance. In addition to these ray-like folds, one often finds at the edge of the disc, folds which run perpendicularly to the rays.

Some of the smaller species of Prionids show the pleural discs only faintly, and then usually best on the first three abdominal segments. However, if one looks carefully, the others may also be found.

Outside of the sub-family Prioninæ, all the species which the writer was able to observe, possessed the elliptical or pleural tubercle. In *Saperda candida*, *Rhagium lineatum*, and *Desmocerus palliatus*, the elliptical enlargements were found on each of the first eight abdominal segments, with a faint evidence of a disc at the posterio-dorsal portion of each tubercle. In many species a slight indication of a disc was also found at the anterio-ventral end of the tubercle.

In *Monohammus confusor* a very peculiar condition was observed. The elliptical enlargement or pleural tubercle was present, but instead of a ray-like structure, or pleural disc, at either end there was found a depression in the form of a chit-

inous invagination, at both the posterio-dorsal and anterio-ventral ends, as shown in Figs. 2 and 4 (C. Inv.). Instead of opening directly laterally, the pockets open at an angle of about 45 degrees directed away from the pleural tubercle.

THE CHORDOTONAL ORGAN.

On examining the larvæ internally, one finds in the case of the Prionids with the pleural discs, that a peculiar structure in the form of a chordotonal ligament is attached at the central point of the disc, and stretched in an anterio-ventral direction across an irregularly shaped enlargement on the pleural zone, and attached at the other end to a fold in the body wall, as is shown in Fig. 5 (Ch. L.). This ligament is very slender for its posterior two-thirds, but soon thickens towards its anterior third, to two or three times the size of the posterior portion. At about one-half the distance between the beginning of this swelling and the anterior attachment, a branch of the first nerve of the corresponding segment enters the structure from the side. This is the chordotonal nerve (Ch. N.). Anterior to the entrance of the nerve, the structure narrows slightly until it attaches. In the case of the organs in the seventh and eighth abdominal segments, the condition is slightly different in that the anterior attachment is at the anterio-ventral end of the pleural tubercle, instead of on an anterior body fold as in the other six pairs. This latter condition exists in all eight of the abdominal segments of such species as *Saperda candida*, *Rhagium lineatum*, and *Desmocerus palliatus*. The fact that the ligament attaches anteriorly at the anterio-ventral portion of the pleural tubercle often causes a faint external evidence of a pleural disc in this region.

In *Monohammus confusor*, the condition is much the same except that at each end of the pleural tubercle, there is a large chitinous invagination (Figs. 2 and 4, C. Inv.) which projects into the body for a short distance. A chordotonal ligament similar to the one described above, is stretched across the ends of these chitinous structures (Fig. 6, Ch. L.).

STRUCTURE OF THE NERVE END ORGAN OR SCOLOPOPHORE.

In the two species, *Ergates spiculatus* Lec. and *Monohammus confusor* Kirby, which were studied for their histological structure, there was found a pair of chordotonal ligaments in each of the first eight abdominal segments. Since these organs were alike structurally, a description of one will suffice for both species. Sections were cut of these ligaments in the different abdominal segments of these two species, and also of *Mallodon dasystomus* Say, and it was found in every case, that each of the eight pairs of cords contained four nerve end organs or scolopophores.

The scolopophores of the cerambycid larvæ correspond in general to those of other orders of insects, and are especially similar to those described by Schwabe (1906). Each is a nerve end organ, composed of a ganglion cell, and two enveloping cells. The ganglion cell or, better, the sense cell, is elongated and covered on its distal end by two enveloping cells, forming a sack-like structure about the distal end of this cell. The distal one of these two enveloping cells serves to unite the end organ with the hypodermis, and is called the cap cell. (Figs. 7 and 8, C. C.). The other one of the two cells (E. C.) lies between the cap cell and the enlarged portion of the sense cell, while proximad to this cell is found the body of the sense cell (S. C.), with its continuation to the nerve (Ch. N.).

The sense cell (Figs. 7, 8 and 9, S. C.), which contains the axis fiber (Fig. 9, A. F.), is of the bipolar nerve type, continuous proximad with the chordotonal nerve (Ch. N.). Its distal portion penetrates the center of the enveloping cell into the proximal end of the cap cell, where the nerve enlarges to form the peg-shaped body or scolopale (Sc.). The cell enlarges in its middle portion, in which region is found a large spherical shaped nucleus, containing large and fine chromatin parts. The cytoplasmic structure is similar to that of other nerve tissues. An axis fiber runs nearly straight through the sense cell, except where it bends around the large nucleus. As it enters the proximal end of the cell, it is very small, but as it approaches the distal end, it gradually becomes much enlarged. However, at the point where it enters the peg-shaped body, or scolopale,

it again becomes very small, and continues as a fine cord until it joins a knob-shaped structure near the apex (the end knob Fig. 9, E. K.).

In the larvæ under consideration, these peg-shaped bodies, or scolopalæ, were found located near together with their distal ends in the region where the thickened portion of the chordotonal ligament begins to taper posteriorly. In this rather narrow region is located the distal end of the posterior of the four scolopalæ, and the other three are arranged in a series anteriorly, so that no two of the four organs are the same distance from the posterior end. These scolopalæ are considered by most authors as the enlarged terminal portions of the axis fibers. However, Schwabe is not of this opinion but considers each as a cap-like enveloping apparatus itself. With this latter interpretation my results do not accord.

In general, the scolopalæ in *Ergates spiculatus* are very much like the ones which Schwabe described for the Orthoptera. At the base of each is a vacuole (Fig. 9, V.) which connects with the hollow central portion and, according to Schwabe, is filled with a watery fluid. The number of outer strands or ribs (Fig. 10 B., R.) of which the scolopale is composed, is different from what Schwabe found, in that there are seven large basal strands which divide a little over one-third their distance distally, making a total of fourteen (Fig. 10 C., R.). The dark cap, or knob, located in the distal portion of the scolopale was found to be composed of seven large, opaque divisions, corresponding to the seven basal parts. (Fig. 10 D., E. K.). However, the exact relation between these and the fourteen ribs could not be determined, though it seems very probable that the ribs pass along the exterior portion of the knob, and form the terminal ligament (Fig. 10 A., T. L.), which extends into the cap cell for about one-fourth the length of this cell. The entire scolopale, except possibly the terminal ligament, is bathed in the watery liquid, and is free to vibrate.

The enveloping cell is a rather large, elongated cell, which lies like a funnel over the greater part of the distal end of the sense cell (Fig. 9, E. C.). It is composed of a light, nearly transparent, alveolar, cytoplasmic structure, with an enlarged nucleus (E. C. N.) towards its proximal end.

The cap cell is located distad of the enveloping cell, and connects it with the body wall (Figs. 7 and 8, C. C.). It contains at its base the distal end of the sense cell, with its scolopale. Structurally, the protoplasm of this cell is of a much denser nature than that of either of the other two cells, but about its proximal portion the protoplasm is not as dense as farther distad. The whole cell is more or less filled with dark staining strands, or fibrils (F.), which pass in a rather winding condition, somewhat as the strands of a rope, to the distal end, where they unite directly to the cuticula (C. C. A.). This cell is exceptionally long and spindle-shaped and, as Weismann suggested, it seems very capable of vibrating. Near its proximal end is a small elliptical nucleus (C. C. N.), containing dark areas of chromatin.

The portion of the chordotonal ligament anterior to the enveloping cells, and at the sides of the sense cells, is composed of a substance which Schwabe called the "fibrillar binding substance." (Figs. 7, and 8, B. S.). This structure begins to appear in the region of the proximal part of the enveloping cells, and continues along the sides of the sense cells to the anterior attachment. It contains many nuclei, but in no case were cell boundaries seen. These fibrillar strands with their nuclei finally occupy the entire cord at its anterior portion, and by means of these fibrils the cord is fastened directly to the cuticula, much in the same way as at the posterior end. Schwabe regards this fibrillar binding substance as a continuation of the covering of the nerve. This idea seems quite plausible from the appearance of this substance about the sense cells. However, when one considers the character of the fibrils, the nuclei, and the method of attachment, it may be interpreted as a separate modified hypodermal structure.

All larvæ that were studied possessed eight pairs of these abdominal organs. The ones at the anterior part of the abdomen were one-fourth to one-half a millimeter longer than those in the posterior segments, while the others formed a proportional gradation in between.

Since the four nerve endings of each cord are so arranged that no two are the same distance from the posterior attachment, it seems very evident that there is a possibility that the larva is able to detect sounds of different wave lengths.

Authors disagree regarding the function of these organs. Graber ('82), Schwabe ('06), Schon ('10), and many others regard them as organs of hearing, but some of the more recent writers, such as Radl ('05) maintain that they have a static function.

No muscles were found which appeared to function in regulating the length of the ligaments, and it seems, so far as could be discerned, that the length is constant. In the Corethra larva these ligaments have been observed to shorten and lengthen in the living animal, but from a study of the chordotonal ligaments in the wood-boring Cerambycid larvæ, it does not seem possible that their length is changeable.

The external covering of the chordotonal ligament is rather thick, due largely to the fact that the basement membrane which covers the hypodermis internally, also forms a covering about this structure.

What relation the tracheal system has to these organs is not certain. Schwabe ('06) found enlarged tracheal sacks in the region of the organs in the Orthoptera. Vogel ('12) found a corresponding relation between the chordotonal organs in the wings of butterflies and the trachea. Lehr ('14) found a similar condition in the wings of *Dystiscus marginalis*. In the abdomen of the forms here studied, a rather large trachea was always observed in close apposition to that part of the chordotonal ligaments which contained the peg-shaped bodies or scolopalæ.

The cuticula at the posterior point of attachment of the chordotonal ligaments in all species studied, and at both ends in *Monohammus confusor*, was found modified into a very hard, dark-staining structure. This condition, together with the arrangement of the scolopalæ in the ligaments, seems to favor the idea that the organs are for hearing, rather than for balancing, since sound waves could easily be transferred by this hardened cuticula to the ligament, which by its vibration, could carry the impulse to the nerve and organ.

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EXPLANATION OF PLATES.

Plate IV.

Fig. 1. Lateral view of the larva of *Mallodon dasystomus* Say. Amb Amp, Ambulatory ampulla; Hy P, hypopleurum; in seg, intersegmental area; pl disc, pleural disc; Pl Tu, pleural tubercle; Pl Z, pleural zone; Pnot, pronotum; P. Scl, postscutellum; S, spiracle; Sp A, spiracular area.

Fig. 2. Lateral view of the larva of *Monohammus confusor* Kirby. Amb Amp, Ambulatory ampulla; C Inv, chitinous invagination; Hy P, hypopleurum; Pl Tu, pleural tubercle; Pnot, pronotum; S, spiracle.

Fig. 3. Enlarged pleural disc of the first abdominal segment of *Mallodon dasystomus* Say. C Pl, center of pleural disc, with chitinous cap; R Pl, ridge of pleural disc.

Fig. 4. Pleural tubercle of the sixth abdominal segment of *Monohammus confusor* Kirby. C Inv, chitinous invagination; Pl Tu, pleural tubercle; Se, seta.

Plate V.

Fig. 5. Left side of the third abdominal segment of *Ergates spiculatus* opened from the dorsal side. A A , anterior attachment of chordotonal ligament; Ch L, chordotonal ligament; Ch N, chordotonal nerve; G Cn, ganglion of central nervous system; Hy P, hypopleurum; in seg, intersegmental area; N, nerve; P A, posterior attachment of chordotonal ligament; Pl Z, pleural zone; S, spiracle.

Fig. 6. Left side of the sixth abdominal segment of *Monohammus confusor* Kirby, opened from the dorsal side. A A, anterior attachment of chordotonal ligament; Ch L, chordotonal ligament; Ch N, chordotonal nerve; C Inv, chitinous invagination; G Cn, ganglion of central nervous system; Hy P, hypopleurum; in seg, intersegmental area; N, nerve; P A, posterior attachment of chordotonal ligament; Pl Tu, pleural tubercle; Pl Z, pleural zone; S, spiracle.

Plate VI.

Fig. 7. Longitudinal vertical section of the pleural tubercle and chordotonal ligament of *Monohammus confusor* showing two scolopophores. A B S, attachment of binding substance, at anterior end; B S, binding substance; B S N, binding substance nucleus; C C, cap cell; C C A, cap sell attachment, at anterior end; C C N, cap cell nucleus; Ch N, chordotonal nerve; C Inv, chitinous invagination; E C, enveloping cell; E C N, enveloping cell nucleus; E K, end knob; F, fibrils of cap cell; Hyp, hypodermis; M C, modified cuticula; P C, primary cuticula; S C_1, secondary cuticula; S C, sense cell; Sc, scolopale; S. C. N, sense cell nucleus; T L, terminal ligament; V, vacuole.

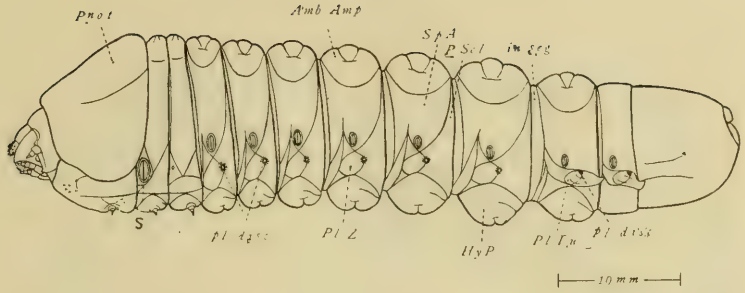
Fig. 8. Longitudinal vertical section of the pleural zone and chordotonal ligament of *Ergates spiculatus* showing two scolopophores; A B S, attachment of binding substance, at anterior end; B S, binding substance; B S N, binding substance nucleus; C C, cap cell; C, chitinous cap; C C N, cap cell nucleus; Ch N, chordotonal nerve; E C, enveloping cell; E C N, enveloping cell nucleus; E K, end knob; F, fibrils of cap cell; Hyp, hypodermis; M C, modified cuticula; P C, primary cuticula; S C_1, secondary cuticula; S C, sense cell; Sc, scolopale; S C N, sense cell nucleus; T L, terminal ligament; V, vacuole.

Plate VII.

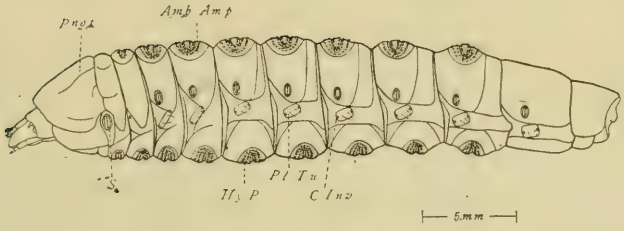
Fig. 9. Enlarged portion of scolopophore. A F, axis fiber; C C, cap cell; C C N, cap cell nucleus; E C, enveloping cell; E C N, enveloping cell nucleus; E K, end knob; F, fibrils of cap cell; Sc, scolopale; S C, sense cell; S C N, sense cell nucleus; T L, terminal ligament; V, vacuole.

Fig. 10. *A* is an enlarged peg shaped body or scolopale with portions of the three cells of the scolopophore. *B* is a cross-section in the region of the proximal portion of the scolopale. *C* is a cross section in the region of the center of the scolopale. *D* is a cross-section in the region of the end knob. A F, axis fiber; C C, cap cell; D S C, distal portion of sense cell; E C, enveloping cell; E K, end knob; F, fibrils of cap cell; Sc, scolopale; R, rib of scolopale; T L, terminal ligament; V, vacuole.

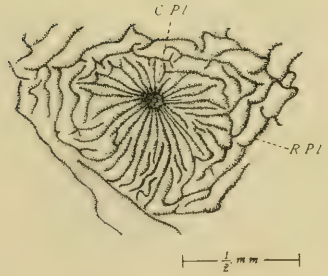
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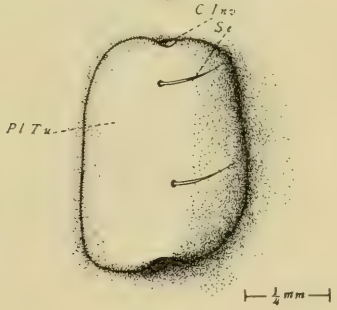
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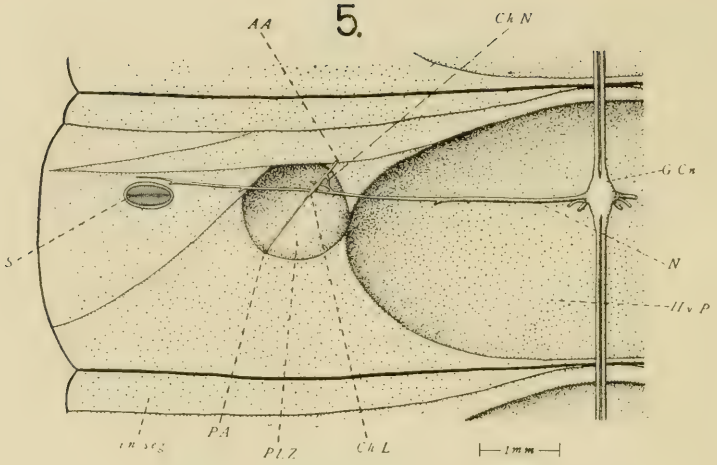
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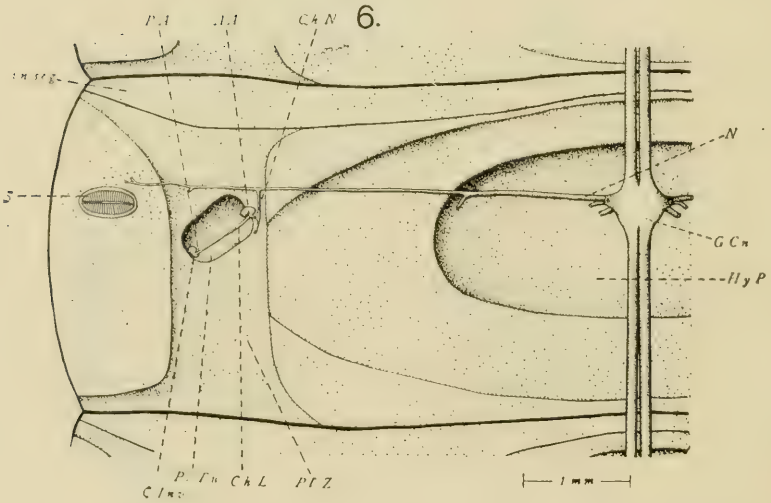

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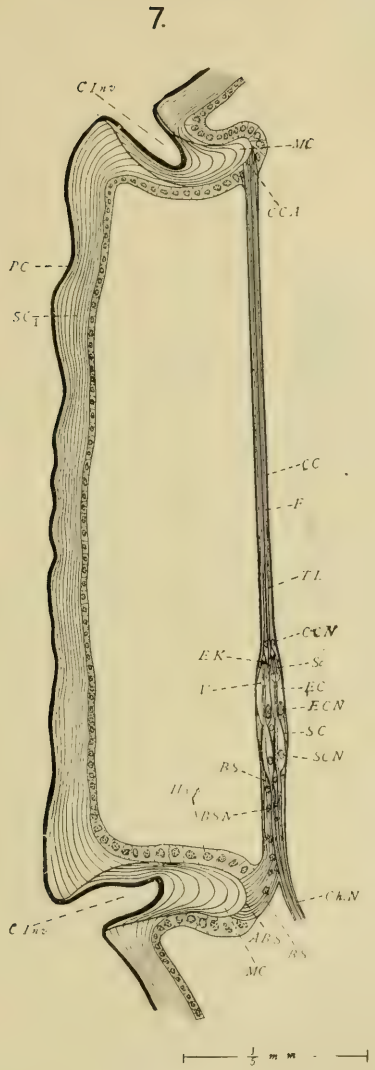

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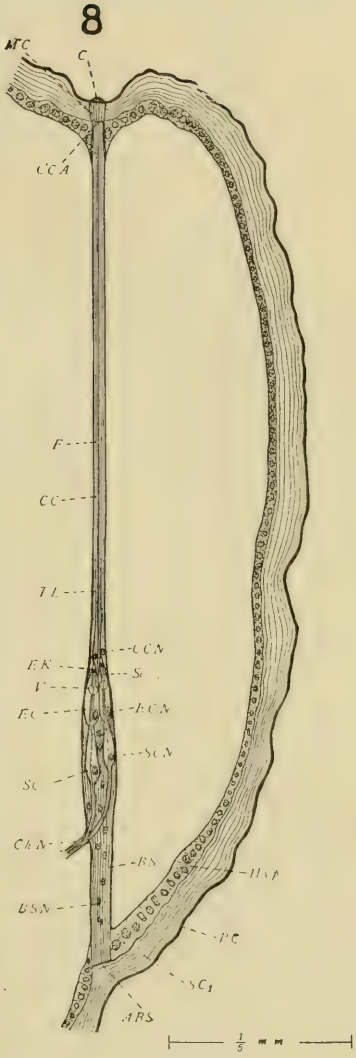
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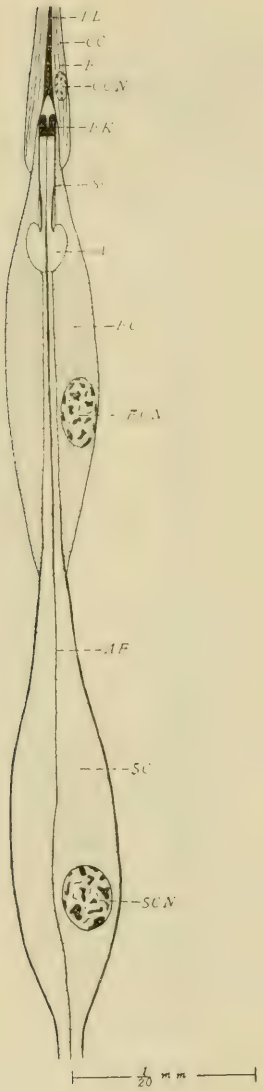
W. N. Hess.


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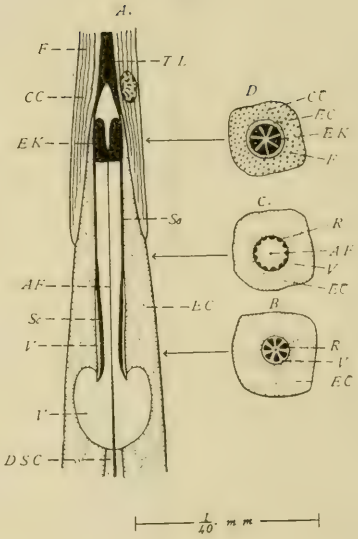

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W. N. Hess.

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W. N. Hess.

THE CICADELLIDÆ (JASSOIDEA-FAM. HOMOPTERA) OF WISCONSIN, WITH DESCRIPTION OF NEW SPECIES.

(With Two Plates).

By J. G. Sanders, Harrisburg, Pa.
and
D. M. DeLong, O. S. U., Columbus, Ohio.

Interesting facts are always brought forth, when comparisons are made of faunal groups of several states. The insect fauna of Wisconsin has received but little attention in the past, because of a lack of entomological work of any considerable range in that state. For this reason it was not surprising that thirteen distinct species new to science were found in the limited group formerly known as the superfamily Jassoidea, but lately changed by Mr. E. P. Van Duzee in his list* to Cicadellidæ.

The Cicadellid faunas of four states east of the Mississippi river have been fairly well determined, viz.: Maine, New York, Tennessee and Wisconsin, and the following table shows at a glance the relative abundance of species of several genera in these regions.

	WIS.	MAINE	N. Y.	TENN.
Cicadellinæ	20	12	21	27
Bythoscopinæ	26	27	31	13
Deltocephalus	26	15	14	25
Euscelis	14	12	11	7
Phelpsius	14	9	10	19
Thamnotettix	17	16	12	11
Chlorotettix	6	4	6	15

The collection of material in this group has been carried on since 1910 by the senior author, but the larger part of the material was collected during the summer of 1916 by both authors, while traveling over the state in nursery inspection

*Check List of Hemiptera of Amer. N. of Mexico, New York Ent. Soc., 1916.

work. The list as determined numbers 206 species and varieties, representing 38 genera, and is second in number of species to the Tennessee list containing 212 species, which was published last year by the junior author.

In Maine, a state with a similar location and having a flora similar to that of Wisconsin, it is interesting to note that of 151 species collected by Professor Herbert Osborn, only 33 species of that list were not taken in Wisconsin, while 108 were found there. In the Tennessee list we find 99 species occurring which have not been taken in Wisconsin, while 113 species are common to both states.

The Wisconsin list has extended the known range of a number of species which were supposed to be restricted to more southern areas. The southern fauna seems to extend up the Mississippi River Valley as far north as St. Paul, and apparently works northward through the deep valleys adjoining this valley. As an instance, *Deltocephalus vinnulus* Crumb, described from Tennessee a year ago, was found in central Wisconsin, while *Acinopterus acuminatus*, a typical southern form, was found well up in Wisconsin, although it is rarely found north of the Ohio River.

The northern portion of Wisconsin, which produces many Canadian forms of vegetation, and is dotted with many lakes and swamps, contains a rather limited number of peculiar species found only under such conditions.

The best collecting for the species of this group is in localities where the vegetation is in its most primitive condition—not having been disturbed by farm practices or any form of cultivation, and in the absence of forest or prairie fires. From these facts we can readily observe that usual farm practices of cultivation and rotation of crops, as well as the burning-over of infested land, are factors in checking the multiplication of these species and their resulting damage to crops.

Leaf hoppers are more or less restricted to certain food plants, although some species seem to have but slight preference. In order to carry on satisfactory economic controls it is necessary to know where and under what conditions these forms occur naturally, and to determine their habits, including egg deposition, the methods of feeding and the form in which the species hibernates.

In the collection of leaf hoppers some interesting points have been determined, including the fact that when the temperature is very high in midsummer at midday, these forms seem to retire to the base of the plant, and are collected with difficulty, but earlier or later in the day they may be found in abundance on the same forms of vegetation. It is, therefore, advisable in collecting in midday to take advantage of open woodlands, or such conditions where the vegetation affords a reasonable amount of protection from the sun. Cloudy days are always advantageous for general collecting for these reasons. Some species, however, always feed very close to the ground, and can, therefore, be taken only by intensive sweeping close to the base of the plant.

It is to be hoped that these interesting forms will be collected more generally in the several states, than they have in the past, and that our economic entomologists will realize more fully the extent of damage which is caused by the millions of tiny sucking individuals occurring frequently in a few acres of pasture.

This list of species is numbered according to the "Check List of Hemiptera," prepared by Mr. E. P. Van Duzee, and published by the New York Entomological Society, 1916. The writers desire to express their appreciation of the kindly assistance and suggestions of Professor Herbert Osborn, in the preparation of this list, and also for the privilege of comparing the specimens with Professor Osborn's valuable collection. We wish also to express our appreciation to Mr. Joseph Knull, Harrisburg, Pa., for assisting in the preparation of the drawings.

Family—CICADELLIDÆ (Latr.) 1825.

Subfamily—BYTHOSCOPINÆ (Dohrn.)

1762. **Agallia novella** (Say)—Generally distributed.
1764. **A. 4-punctata** (Prov.)—Common.
1767. **A. sanguinolenta** (Prov.)—Common.
1777. **Idiocerus nervatus** VD.
1778. **I. pallidus** Fh.
1779. **I. suturalis** Fh. A fairly common species.
1779a. **I. suturalis var lunaris** Ball.
1781. **I. alternatus** Fh.
1782. **I. verticis** (Say).
1795. **I. lachrymalis** Fh.

Idiocerus subnitens n. sp.
(Figs. 1, 2, 3.)

Resembling *I. lachrymalis* in shape, slightly smaller and shiny, with a distinct brown median transverse band. Length 6 mm.

Vertex broad and very short; longer next eye than at middle, anterior margin slightly produced. Pronotum two and one-half times as wide as long; humeral angles broadly rounded and posterior margin slightly excavated. Elytra rather long, greatly overlapping at apex and well rounded; venation strong. Face broad, front almost as broad as long, margins angled at antennæ, gradually and evenly narrowed to clypeus. Loræ long, outer margins slightly rounded. Antennal pits unusually deep.

Color: Vertex pale yellow; two round spots in pits, a broad band just beneath with a spot extending back next either eye, and two extending back and diverging on the margin, black. A transverse row of four rather large white spots include the antennæ. Front, upper half pale; lower portion, clypeus and inner portions of loræ, dark brown. Pronotum pale, irregularly marked with dark brown forming four rather distinct blotches, one in either humeral angle and one either side of middle on the disc. Scutellum yellow, basal angles, two round spots on disc and a median line between them dividing just back of middle and extending to apex, dark brown. Elytra dark brown, iridescent; inner margin of clavus, and a transverse band just back of clavus milky white, subhyaline, apex smoky hyaline. Beneath light brown.

Genitalia: Female last ventral segment almost twice as long as preceding; rather evenly rounded from base to produced apex. Pygofers broad and stout, much exceeded by ovipositor.

Described from one female specimen swept from poplar at Tomah, Wis., August 2, 1916. This mature specimen differed so considerably from any known species by several well marked characters that it was thought advisable to describe it specifically.

1797. **I. snowi** G. & B.
1800. **I. cratægi** VD.—One specimen St. Croix Falls, Aug. 16, 1916.
1801. **I. provancheri** VD.
1807. **Macropsis gleditschiæ** (O. & B.)—Madison, Milwaukee.
1808a. **M. virescens var graminea** (Fabr.).—Southern part of state.
1809. **M. viridis** (Fh.).
1810. **M. occidentalis** VD.—Southern part of state.
1815. **M. basalis** (VD.)—Southern area.
1818. **M. bifasciata** (VD.)—Southern.
1824. **Oncopsis variabilis** (Fh.).
1825. **O. sobrius** (Walk)—Southern points.
1828. **O. fitchi** VD.—Southwestern points.

1829. **O. pruni** (Prov.)—One spec., Pembine, June 21, 1913.
1831. **O. nigrinasi** (Fh.)One spec., St. Croix Falls, Aug. 15, 1916.
1832. **O. fagi** (Fh.)—Southern.
1833. **O. distinctus** (VD.)—Southern.

Subf. CICADELLINÆ VD.

1847. **Oncometopia lateralis** (Fabr.)—General.
1847a. **O. lateralis var. limbata** (Say)—St. Croix Falls, Aug. 16, 1916.
1854. **Cicadella hieroglyphica** (Say.)—Gay's Mills, June 29, 1916.
1855. **C. gothica** (Sign.)—Abundant throughout state.
1859. **Kolla bifida** (Say.)—Sparingly in western areas of state.
1863. **Helochara communis** Fh.—Generally distributed.
1864. **Graphocephala coccinea** (Forst).—Common.
1873. **Draeculacephala angulifera** (Walk.)
1874. **D. mollipes** (Say).—Common.
1875. **D. minor** (Walk).—Common.
1879. **D. noveboracensis** (Fh.)
1884. **Eucanthus acuminatus** (Fabr.)—St. Croix Falls, Aug. 15, 1916. In damp undergrowth.

Subf. GYPONINÆ.

1894. **Penthimia americana** Fh.—3 spec. Lk. Geneva, Grand Rapids, Tomah.
1896. **Gypona rugosa** Spangb.—3 specimens, Merrillan.
1897. **G. 8-lineata** (Say).—Generally distributed.
1898. **G. cana** Burm.
1904. **G. striata** Burm.—4 spec. Camp Douglass, Sturgeon Bay; Taylors Falls, Minn.
1910. **G. bipunctulata** Woodw.—One specimen, Colfax, Aug. 9, 1916.
1917. **G. pectoralis** Spangh.—2 spec., Blue River, Lk. Geneva.
1923. **G. scarlatina** Fh.—3 spec., Madison, Camp Douglas.

Subf. JASSINÆ.

1936. **Acucephalus albifrons** (Linn.)—Two spec., Monroe, July 25, 1916.
1940. **Xestocephalus pulicarius** VD.—General.
1941. **X. superbus** (Prov.)—Central and northern.
1943. **X. coronatus** O. & B.—2 spec., Amery, Aug. 11, 1916; Woodruff, Sept. 8, 1916.
1956. **Parabolocratus major** Osb.—General.
1957. **P. flavidus** Sign.—Two specimens, Madison, July 9, 1916.
1972. **Mesamia nigridorsum** Ball.—One spec., Grand Rapids, Aug. 21, 1916.
1975. **M. vitellina** (Fh.)—A northern species.
1983. **Scaphoideus auronitens** Prov.—General.
1984. **S. jucundus** Uhl.—Northern.
1988. **S. scalaris** VD.—Fairly common.
1989. **S. lobatus** VD.—Three spec., Woodman, July 27, 1916; Marshfield, Aug. 20, 1916.

1990. **S. ochraceus** Osb.—Three spec., Woodman, July 27, 1916; Amery, Aug. 10, 1916.
1991. **S. productus** Osb.—Generally northern.
1994. **S. intricatus** Uhl.
1996. **S. immistus** (Say).—Common.
1996. **S. immistus var. minor** Osb.—Common.
2014. **Platymetopius acutus** (Say).
2014a. **P. acutus** var. **dubius** VD.—Sixteen specimens, Ladysmith, Aug. 9, 1916.
2017. **P. cuprescens** Osb.—Northern.
2019. **P. cinereus** O. & B.—Madison & Woodman (July, Aug.).
2020. **P. augustatus** Osb.—Two spec., Camp Douglas, Aug.1, 1916.
2023. **P. frontalis** VD.—Common at southern points.
2029. **P. magdalensis** Prov.
2033. **Deltocephalus bilineatus** G. & B.—Amery, Aug. 13, 1916; Marshfield, Aug. 20, 1916.

Deltocephalus luteocephalus n. sp.
(Figs. 19, 20, 21, 22.)

This beautiful species is readily distinguished by the ivory yellow head and orange red ocelli; elytra and general coloration resembling *D. bilineatus*. Length 3.5–4 mm.

Vertex convexly produced, pointed, twice as long in middle as next the eye, slightly wider than long. Pronotum equal to vertex in length, humeral angles evenly rounded to the almost truncate posterior margin. Elytra long and rather narrow, apex evenly rounded; nervures distinct. Face rather broad; front convex, evenly narrowed to the clypeus which is broader at apex than base. Antennal pits deep.

Color: Vertex white to ivory yellow; ocelli orange red and a median black suture on basal two thirds. Anterior margin of pronotum ivory white, darker posteriorly. Scutellum yellow. Face immaculate, ivory yellow, antennal pits black. Elytra smoky subhyaline; claval, discal and apical cells darker. Costal and apical cells darker brown distally. Nervures white margined with brown. Beneath pale.

Genitalia: *Female* last ventral segment rather long, broadly and slightly emarginate, with a shallow rounded notch at middle between two black spots. Pygofers beset with long brown hairs at apex. *Male* valve very short, broadly rounded. Plates large, convexly narrowed to bluntly rounded apices, each with a large brown spot near tip. Pygofers densely clothed with brown hairs.

A pair from Madison, (Lake Wingra), July 1, 1916.

2034. **D. imputans** O. & B.—Grand Rapids, Aug. 21, 1916.
2039. **D. inflatus** O. & B.—Tomah and Grand Rapids (Aug.).
2044. **D. reflexus** O. & B.—Grand Rapids and Taylors Falls, Minn., (Aug.)
2045. **D. pectinatus** O. & B.—One spec., Madison, July 9, 1916.

2048. **D. abbreviatus** O. & B.—Two spec., St. Croix Falls, Aug. 16, 1916; Grand Rapids, Aug. 21, 1916.
2049. **D. stylatus** Ball.—One spec., Grand Rapids, Aug. 21, 1916.
2051. **D. configuratus** Uhl.—One spec., Pembine, Sept., 4, 1916.
2053. **D. sayii** (Fh.)—Common. July and August.
2054. **D. missellus** Ball.—Common.
2055. **D. weedi** VD.—One specimen, Blue River, July 28, 1916.
2059. **D. compactus** O. & B.—Not common, generally distributed.

Deltocephalus nigriventer n. sp.

(Figs. 23, 24, 25, 26).

Resembles *D. compactus* in size and form, but with unique genitalia. 2.50–2.75 mm. long.

Vertex obtusely angled, two thirds as long as width between the eyes. Pronotum slightly longer than vertex, anterior margin strongly convex to humeral angles, truncated posteriorly. Elytra short and broad, exceeding the abdomen; venation indistinct. Face broad, convexly rounded to a quadrangular clypeus; loræ semi-circular.

Color: Two apical spots just anterior to a broad sinuate band, interrupted at middle, connecting the eyes, and ocelli, black. Pronotum milky gray, anterior half vaguely mottled with brown. Scutellum with basal angles and median stripe black. Elytra milky gray, subhyaline; clavus irregularly mottled with brown; a large spot each on discal cell, third anteapical cell and midway on costal margin, black. Nervures milky white. Face black with several pairs of pale lateral arcs. Clypeus with median black stripe forming a spot at apex; loræ margined with black. Venter black, segments pale margined.

Genitalia: *Female* last ventral segment twice as long as preceding, produced, broadly truncate, incised nearly to base; margins of incision almost overlapping, roundingly angled. Ovipositors and pygofers dull black, the latter beset with many short paler bristles posteriorly. *Male* valve scarcely longer than preceding segment, obtusely pointed. Plates large, broadly convex, tapering to rounded, upturned points; margin and dorsal surface with pale hairs.

Six females and two males from Merrillan, August 5, 1916, and one female from Tomah, August 2, 1916, were swept from small grasses. The female genitalia are decidedly unique for the genus.

2060. **D. vinnulus** Crumb.—Four specimens, Grand Rapids, Aug. 21, 1916. These specimens agree exactly with cotypes from Tennessee.
2062. **D. apicatus** Osb.—One specimen Merrillan Jt., Aug. 5, 1916.
2063. **D. inimicus** (Say)—Generally distributed.

Deltocephalus fumidus n. sp.

(Figs. 11, 12, 13, 14).

Uniform smoky brown iridescent, with black ocelli. Length 4.5 to 5 mm.

Vertex similar to **D. inimicus,** about as long as width between the eyes, flat. Pronotum twice as wide as long, and one-half longer than vertex, strongly convex anteriorly; humeral angles sloping sharply to truncate posterior margin. Elytra long, strongly curved on costal margin, rounded at apex. Front convex, triangular, evenly narrowed to the rectangular clypeus. Loræ small, narrow and distant from margin.

Color: Vertex pale, shading to smoky brown at apex; ocelli conspicuously black, encircled with white. Pronotum, scutellum and elytra vitreous pale brown. Nervures paler, narrowly margined with brown. Face smoky shading to lighter on clypeus and genae. Abdomen above black, beneath pale grey.

Genitalia: *Female* last ventral segment longer than preceding; posterior margin truncated and slightly sinuated and infuscated either side or middle. Ovipositor black, pygofers long and thickly clothed with dark hairs on apical third. *Male* valve short, triangular, inserted in the concavity of preceding segment; plates long, broad at base, and concavely narrowed to pointed apices. A single row of hairs on outer margin. Base of each plate with a median brown spot. Pygofers densely clothed with brown hairs.

One female and thirteen males at Woodman, July 27, 1916.

2071. **D. debilis** Uhl.—One specimen, Colfax, Aug. 9, 1916.
2075. **D. melsheimerii** Fh.—Common in northern localities.
2079. **D. affinis** G. & B.—Common.

Deltocephalus concinnus n. sp.

(Figs. 4, 5, 6).

Form and size of *D. affinis,* with two parallel brownish stripes on vertex, pronotum and scutellum. Length 3.25–3.50 mm.

Vertex flat, as long as wide, bluntly angled. Pronotum equaling vertex in length, strongly convex to the broadly rounded humeral angles, posterior margin truncate. Elytra rather long, just exceeding abdomen, tips broadly rounded and slightly flaring. Face about as broad as long, sutures of front and clypeus forming a straight line.

Color: Testaceous; ocelli black; vertex, pronotum and scutellum with two broad parallel brownish stripes; pronotum with an additional stripe behind either eye. Nervures white. Abdomen pale orange above. Venter yellow. Face dusky; a median line and traces of several pairs of arcs, dull yellow.

Genitalia: *Female* last ventral segment slightly longer than preceding; almost truncate with median brown spot. Pygofers robust; posterior two thirds with many pale hairs.

Two females collected at Ladysmith, August 9, 1916.

2081. **D. oculatus** O. & B.—General in northwestern localities.
2083. **D. sylvestris** O. & B.—Generally distributed.
2090. **D. osborni** VD.—Rather generally distributed in central and northern areas.
2097. **D. balli** VD.—Madison, July 21, 1916; Amery, Aug. 14, 1916.
2126. **Driotura gammaroides** (VD).—One spec., Merrillan, Aug. 3,1916.
2131. **Euscelis exitiosus** (Uhl.)—Southern portion of state.
2132. **E. striolus** (Fall.)—Generally distributed.
2133. **E. parallelus** (VD.)—Generally distributed.
2134. **E. extrusus** (VD.)—Lake Geneva, June 21, 1916; Pine Lake, July 16, 1916.
2138. **E. uhleri** (Ball)—One spec., St. Croix Falls, Aug. 16, 1916.
2142. **E. arctostaphyli** (Ball)—1 spec., Madison, July 22, 1916.
2143. **E. humidus** (Osb.)—In bog at Ladysmith, Aug. 9, 1916.
2144. **E. striatulus** (Fall.)—Pembine, Trout Lk., Amery (Aug. and Sept., 1916).
2145. **E. vaccini** (VD.)—Pembine, Merrillan, Amery (Aug. and Sept., 1916).
2146. **E. instabilis** (VD.)—Trout Lake, Aug. 6, 1913; Ladysmith, Aug. 9, 1916.

Euscelis deceptus n. sp.

(Figs. 40, 41, 42).

Coloration and general appearance of *D. osborni*, but lacking the venation of *Deltocephalus* and definite markings. Dull testaceous. Length 5.5–6 mm.

Vertex short and broad, rounding to front, almost twice as long on middle as next the eye; two and one-half times as broad as long. Width of pronotum more than twice the length; lateral margins distinct, humeral angles broadly rounded to shallow emargination posteriorly. Elytra broad, subhyaline, exceeding the abdomen in length; apices well rounded. Front equal in length and breadth, well rounded to the quadrangular clypeus.

Color: Vertex testaceous, with an indistinct brown transverse band, sometimes interrupted in middle, on center of disk. Ocelli bright red. Pronotum dull testaceous, with a row of four to six very indistinct spots just behind anterior margin. Scutellum with two discal spots and apical angle brownish. Elytra a dirty yellow, with intermediate brown markings. Venation usually indistinct. Venter pale bordered with brown. Face pale testaceous, several pairs of arcs on front, sutures, and margins of loræ, brown.

Genitalia: *Female* last ventral segment, twice as long as preceding, broadly excavated with a black spot and a small tooth at the middle. Lateral margins of segment and ovipositor black. Pygofers bright yellow, posterior half evenly clothed with brown hairs. *Male* valve narrow, triangular, apex rounded; plates short and broad, convexly rounding to blunt apex with a marginal row of hairs. Discs of valve and plates with a brown spot.

Females collected: One each, Milwaukee, July 18, 1916; Madison, July 1, 1916, and July 21, 1916; Chicago, Ill., June 24, 1910. Males: One at Chicago, June 24, 1910, and one short-winged male from Fryeburg, Me., September 5, 1913.

2148. **E. elongatus** (Osb.)—Milwaukee, Madison, Pembine (July).
2156. **E. curtisii** (Fh.)—General.
2160. **Eutettix luridus** (VD.)—Eleven spec., Trout Lake, Sept. 7, 1916.
2161. **E. marmoratus** VD.—Four specimens, St. Croix Falls, Aug. 16, 1916.
2163. **E. subaeneus** (VD.)—One specimen from Madison referred to this species.
2179. **E. seminudus** (Say).
2180. **E. cintus** O. & B.—One spec., Grand Rapids, Aug. 21, 1916.
2181. **E. strobi** (Fh.)—One specimen, Milton Jct., Sept. 12, 1911.
2195. **Phlepsius majestus** O. & B.—One spec., Woodruff, Sept. 8, 1916.
2201. **Ph. decorus** O. & B.—Four spec., Grand Rapids, Aug. 21, 1916; Trout Lake, Sept. 7, 1916.
2204a. **Ph. cumulatus** var **arctostaphylae** Ball.—Abundant at Taylors Falls, Minn., just across the St. Croix river from St. Croix Falls, Wis., Aug. 16, 1916; from Partridge berry (**Michella repens**).
2221. **Ph. altus** O. & B.—One specimen, Woodman, July 27, 1916.
2223. **Ph. incisus** VD.—Three specimens, Blue River, July 28, 1916.

Phelpsius umbrosus n. sp.
(Figs. 15, 16, 17, 18).

A dark brown robust species resembling *P. incisus* in form and size. Head scarcely narrower than pronotum. Length 6–6.5 mm.

Vertex obtusely angled, almost twice as long in middle as next the eye; breadth three times the length. Pronotum very strongly convex, twice the length of vertex, and two and a half times as wide as long. Elytra broad, well rounded at tips. Face slightly longer than broad; frontal sutures straight to clypeus, which is broadest at apex; loræ broad, evenly rounded and approximating the margin.

Color: Vertex evenly irrorate, with pale spot at the base next each eye; ocelli pale. Pronotum evenly irrorate and punctulate. Elytra milky white, rather densely and evenly inscribed with dark brown. Face dark brown, evenly irrorate with testaceous.

Genitalia: *Female* last ventral segment twice the preceding in length; lateral angles produced and sharply rounded to an arcuate posterior margin incised at middle, forming two produced broadly rounded lobes, margined by a large semicircular brown spot extending half way to the base. *Male* valve almost equaling last ventral segment in length, slightly concave to an obtuse point. Plates long, evenly narrowed to small blunt points; each outer margin with a few stout bristles.

One female and two males, Grand Rapids, August 21, 1916.

2228. **Ph. irroratus** (Say)—Common.
2230. **Ph. collitus** Ball.—Amery and Tomah, Aug. 13, 1916.
2234. **Ph. lobatus** Osb.—Grand Rapids, Aug. 21, 1916; Taylors Falls, Aug. 16, 1916.
2236. **Ph. apertus** VD.—Two specimens, Trout Lake, Aug. 6, 1913; Pembine, Sept. 4, 1916.
2237. **Ph. fulvidorsum** (Fh.)—One spec., St. Croix Falls, Aug. 15, 1916.
2246. **Ph. solidaginis** (Walk.)—Common in western central areas.

Phelpsius bifidus n. sp.

(Figs. 7, 8, 9, 10).

Resembling *P. solidaginis* in general appearance, but smaller and with distinct genitalia. Length 6–6.5 mm.

Vertex sharp margined, slightly produced and upturned; disc concave, almost twice as long on middle as next the eye; width between the eyes two and one half times the length. Pronotum almost twice as long as vertex, humeral angles well rounded, disc with coarse punctures. Elytra broad, well rounded and flaring at the tips. Face almost as broad as long; front concave below margin, strongly narrowed from antennal pits to clypeus.

Color: Vertex pale, rather heavily irrorate with brown; a spot on upturned apex and one near each eye at either side of base, pale. Narrow anterior margin of pronotum pale, posteriorly dark with light punctures. Elytra milky white, sparsely irrorate except on discal cell and apex of clavus. Veins, a dark spot on base of inner apical cell and four spots on costa, each one at termination of apical costal veins, brown. Face heavily irrorate with brown above, causing it to appear dark in color. Below showing traces of a median line and five pairs of pale arcs. Beneath dark brown, differing greatly from other species.

Genitalia: *Female* last ventral segment twice as long as preceding, strongly produced, angularly rounded to a deep "V" shaped incision, extending more than half way to base. Incision margined with brown. *Male* valve as long as preceding segment, obtusely triangular, plates three times as long as valve, broad and convex at base, then narrowing concavely to blunt points. Margins only beset with short heavy bristles and marked with black points.

Four specimens, two females from Trout Lake, August 6, 1913, and September 7, 1916, and two males from Amery, August 13, 1916, and Woodruff, September 8, 1916.

2247. **Ph. ramosus** (Baker).
2249. **Acinopterus acuminatus** VD.—One specimen from brake ferns(?) at Camp Douglas, Aug. 1, 1916.
2262. **Thamnotettix cockerelli** Ball.—One specimen, Woodruff in extreme northern portion of state, Sept. 8, 1916.
2263. **Th. morsei** Osb.—Three specimens, Trout Lake in northern part of state, Sept. 7, 1916.
2265. **Th. clitellarius** (Say).—Generally distributed.
2286. **Th. atridrosum** VD.—Six specimens from northern localities.
2292. **Th. chlamidatus** (Prov.)—Pembine, July 26, 1916.
2305. **Th. melanogaster** (Prov.)—Generally distributed.

Thamnotettix stramineus n. sp.

(Figs. 27, 28, 29, 30, 31.)

Bright shining straw yellow with two narrow black dashes on margin of vertex. Length 6.5–7 mm.

Vertex very bluntly angled, one-half as long as broad, and half longer in middle than next the eye. Pronotum one-half longer than the vertex, with humeral angles broadly rounded, posterior margin nearly truncate. Elytra one-third longer than the abdomen, clavus extending to tip of abdomen. Face broad, roundingly convex and suddenly narrowed to the quadrangular clypeus.

Color: Vertex yellow, margin with two short transverse dashes and a point on either side, black. Anterior margin of pronotum with yellow band, remainder shiny greenish yellow or darker, scutellum dull yellow. Elytra greenish yellow, subhyaline, shiny; nervures yellow. Beneath yellow in female; black margined with yellow in male; legs yellow. Face yellow, lateral sutures and antennal pits sometimes black.

Genitalia: *Female* last ventral segment as long as preceding, strongly produced with broad, shallow posterior emargination; a black raised disk on each side, embossed with deep converging striæ. These disks joined by a brown or black band in dumb-bell fashion. Pygofers pale with long yellow hairs on posterior two-thirds. Ovipositor slightly darker. *Male* valve large and strongly convex, apex broadly rounded; plates as long as valve, divergent, convexly produced to a sharp black point; pygofers long, black at extreme tips and bearing an unusual number of long white hairs.

Specimens collected as follows: Ladysmith, Aug. 9, 1916, seven females and four males; Amery, Aug. 13, 1916, two females; Madison, July 22, 1916, one female and two males; Blair, Aug. 8, 1916, one female; Marshfield, Aug. 20, 1916, six females.

2306. **Th. ciliatus** Osb.—At Madison on sedges, Aug. 30, 1916.
2307. **Th. decipiens** Prov.—In extreme north of state on sedges.
2308. **Th. smithi** VD.—General.
2312. **Th. fitchii** VD.—Common.
2314. **Th. nigrifrons** (Forbes).—Common in southern part of state.
2318. **Th. inornatus** VD.—Northern localities on wild rye.

Thamnotettix mellus n. sp.

(Figs. 46, 47, 48, 49.)

A small, shiny, yellow, unmarked species, 4.5–5 mm. in length.

Vertex short, obtusely angled, less than one-half longer on middle than next the eye, and nearly twice as long as broad. Pronotum nearly twice as long as vertex, humeral angles broadly rounded, and posterior margin nearly truncate. Elytra relatively long, much exceeding abdomen. Nervures distinct. Face short, broad and suddenly narrowed to the clypeus which is broadened and well rounded at the apex.

Genitalia: *Female* last ventral segment long, lateral angles broadly concave emargination enclosed by a lunular brown area. Ovipositor and pygofers long, the latter with many long pale hairs on posterior two-thirds. *Male* valve very short, evenly rounded, one-half length of previous segment; plates long triangular, gradually tapered to blunt points, outer margin clothed with pale hairs.

Color: Vertex and face smoky yellow, unmarked. Anterior margin of pronotum and scutellum, pale yellow; posterior margin darker. Elytra dull pale yellow, clavus washed with brighter yellow. Venter and legs yellow; tarsal claws black.

A pair from Trout Lake, Vilas Co., August 6, 1913.

2319. **Th. placidus** Osb.—At northern points.
2320. **Th. cyperaceus** Osb.—General on sedges.

Thamnotettix vittipennis n. sp.

(Figs. 36, 37, 38, 39.)

Resembling *Th. cyperaceus* in general appearance. Vertex more rounded and with black marginal line as in *Th. smithi*. Length 5.5–6 mm.

Vertex one-half longer on middle than next the eye, evenly rounded, half as long as width between the eyes. Front evenly rounded to clypeus which is widened and almost truncate at apex. Pronotum about one-half longer than vertex, slightly emarginate behind; humeral angles broadly rounded. Elytral nervures distinct.

Color: Vertex with broad tawny band covering disc and extending to eyes; posterior central portion pale with a median suture; ocelli red; stripe on margin connecting eyes black. Face light, sutural lines of front black. Pronotum tawny to testaceous, anterior margin lighter.

Elytra tawny, subhyaline, nervures white margined with brown, appearing striped. An indistinct brown band extends from humeral angles to the tips of elytra, interrupted by the pale nervures. Venter black, margined with yellow; ovipositor and tips of male plates black.

Genitalia: *Female* last ventral segment as long as preceding, longitudinally striated; posterior border slightly emarginate and narrowly notched either side of middle; pygofers long beset with long brownish bristles. *Male* valve broad, long, apex roundingly angled. Plates short, broadly and convexly rounded, posterior half diverging to a black rugose blunt point. Posterior half beset with many long white bristles.

Four specimens, a pair from Trout Lake, Sept. 7, 1916, and two males from Ladysmith, Aug. 9, 1916, were swept from sedges in low swampy ground.

2324. **Chlorotettix unicolor** (Fh.)—Common and generally distributed.
2326. **Ch. spatulatus** O. & B.—In northwestern localities.
2327. **Ch. tergatus** (Fh.)—Throughout the State.
2331. **Ch. galbanatus** VD.—At northwestern points.

Chlorotettex borealis n. sp.

(Figs. 32, 33, 34, 35.)

Resembling *C. vividus* in shape, but slightly smaller and with distinct genitalia. Length 5 mm. Much smaller than any other known northern species.

Vertex obtusely angled, slightly more than one-half longer on the middle than next the eye, twice as broad as long. Anterior margin of pronotum strongly convex; posterior margin slightly concave; lateral angles broadly rounded. Elytra smoky hyaline.

Color: Resembling **C. vividus** in color, more of grass green than found in most species of the genus. Last ventral segment of female with a dark median stripe from the apex of the incision to the base of the segment. Ovipositor dark. Tibia and tarsi of front legs brownish.

Genitalia: *Female* last ventral segment twice as long as preceding, lateral angles well rounded. A rather broad median notch extending half way to the base; sides convexly angled posteriorly. *Male* valve twice as long, triangular with rounded apex. Plates rather long, convexly rounded to rather blunt tips. Hairs mostly on margin and dorsal surface.

A pair were swept from grass in a clearing at Trout Lake, Sept. 7, 1916.

2336. **Ch. lusorius** O. & B.—At central and northern points.
2340. **Jassus olitorius** Say.—Two specimens, Woodman, July 27, 1916; Tomah, Aug. 2, 1916.
2343. **Neocoelidia tumidifrons** G. & B.—One spec., Tomah, Aug. 2, 1916.

2356a. **Cicadula punctifrons** var. **repleta** Fieb.—Two specimens from Augusta, Aug. 4, 1916.
2358. **C. variata** (Fall.)—Common.
2359. **C. lepida** VD.—Common.
2362. **C. 6-notata** (Fall.)—Common.
2368. **C. slossoni** VD.—Merrillan & Tomah, Aug. 2, 1916.
2370. **Balclutha punctatus** (Thunbg.)—Common.
2371. **B. osborni** VD.—General.
2373. **B. impictus** (VD.)—General.
2377. **Eugnathodus abdominalis** (VD.)
2380. **Alebra albostriella** (Fall.)—Southern points.
2384. **Dicraneura cruentata** Gill.—St. Croix Falls, Aug. 16, 1916.
2386. **D. mali** (Prov.)—Common.
2387. **D. abnormis** Walsh.—Two specimens, Blue River, July 28, 1916.
2393. **D. fieberi** (Loew.)—Common.
2395. **Empoasca smaragdula** (Fall.)—Three spec., Madison, Merrillan and Gay's Mills.
2396. **E. aureoviridis** (Uhl.)—Three spec., Madison, June 10, 1912; Greenwood, Aug. 19, 1916.
2397. **E. unicolor** Gill.—One specimen, La Crosse, Aug. 7, 1916.
2398. **E. obtusa** Walsh.
2401. **E. atrolabes** Gill.
2403. **E. denticula** Gill.—One spec., Pembine, July 26, 1910.
2416. **E. snowi** Gill.—Southern.
2421. **E. mali** (LeB.)—Common.
2422. **E. flavescens** (Fabr.)
2423. **E. viridescens** Walsh.—One spec., Amery, Aug. 11, 1916.
2424. **E. birdii** Goding—Three spec., Marshfield, Aug. 20, 1916; Amery, Aug. 16, 1916.
2428. **Typhlocyba nigra** (Osb.)—One spec., Amery, Aug. 14, 1916.
2429. **T. flavoscuta** (Gill.)—Common at Marshfield, Aug. 20, 1916, on ferns in dark woods. Also at Greenwood and Amery.
2430. **Empoa querci** Fh.—Common at Madison.
2430a. **E. querci** var. **bifasciata** (G. & B.)—Common.

Empoa aureotecta n. sp.

(Figs. 43, 44, 45).

Size and form of *E. querci;* basal two thirds of elytra uniform orange yellow without pattern. Length 3.75 to 4 mm.

Head produced, scarcely angled, almost a third longer on the middle than next the eye. Pronotum twice as long as the vertex. Elytra rather long, nervures indistinct.

Color: Vertex pronotum and scutellum bright yellow unmarked. Elytra uniform orange yellow from base to tip of clavus, whitish hyaline beyond, apex faintly smoky. Face, legs and venter pale yellow. Pygofers and ovipositor bright yellow, the apex of the latter, black.

Genitalia: *Female* last ventral segment twice as long as preceding, much produced, gradually rounding from lateral angles to a keeled, blunt apex. Pygofers stout, a row of short hairs either side of ovipositor.

Three female specimens swept from oak at Madison, July 9, 1916.

2434. **E. commissuralis** (Stal.)
2435. **E. tenerrima** (H. S.)—One spec., Bayfield (in extreme north), Sept. 10, 1916.
2437. **E. rosae** (Linn.)—Generally distributed.
2440. **Erythroneura trifasciata** (Say)—Generally distributed.
2441. **E. tricincta** Fh.—Madison and Lk. Geneva.
2443. **E. hartii** (Gill.)—Four specimens from Taylor's Falls, Aug. 16, 1916.
2445. **E. comes** (Say).—Common.
2445a. **E. comes** var. **vitifex** Fh.
2445b. **E. comes** var. **zicza**c Walsh.
2445c. **E. comes** var. **vitis** (Harr.)—Common.
2445d. **E. comes** var. **basilaris** (Say)—Amery, Aug. 11, 1916.
2445f. **E. comes** var. **rubra** Gill.
2445g. **E. comes** var. **maculata** Gill.—Madison.
2446. **E. illinoiensis** (Gill.)—Baraboo and Marshfield.
2447. **E. obliqua** (Say).
2447b. **E. obliqua** var. **noevus** (Gill.)—Lk. Geneva and Madison, June 21, 1916.
2447c. **E. obliqua** var. **fumida** (Gill.)—St. Croix Falls, Aug. 15, 1916.
2448. **E. vulnerata** Fh.
2448a. **E. vulnerata** var. **niger** (Gill.)—Amery, Aug. 11, 1916.

A total of 206 species and varieties, including 13 new species, are listed above. Additional species common to Iowa and Illinois should be found by collecting in the southwestern counties of Wisconsin near the Mississippi river.

EXPLANATION OF FIGURES.

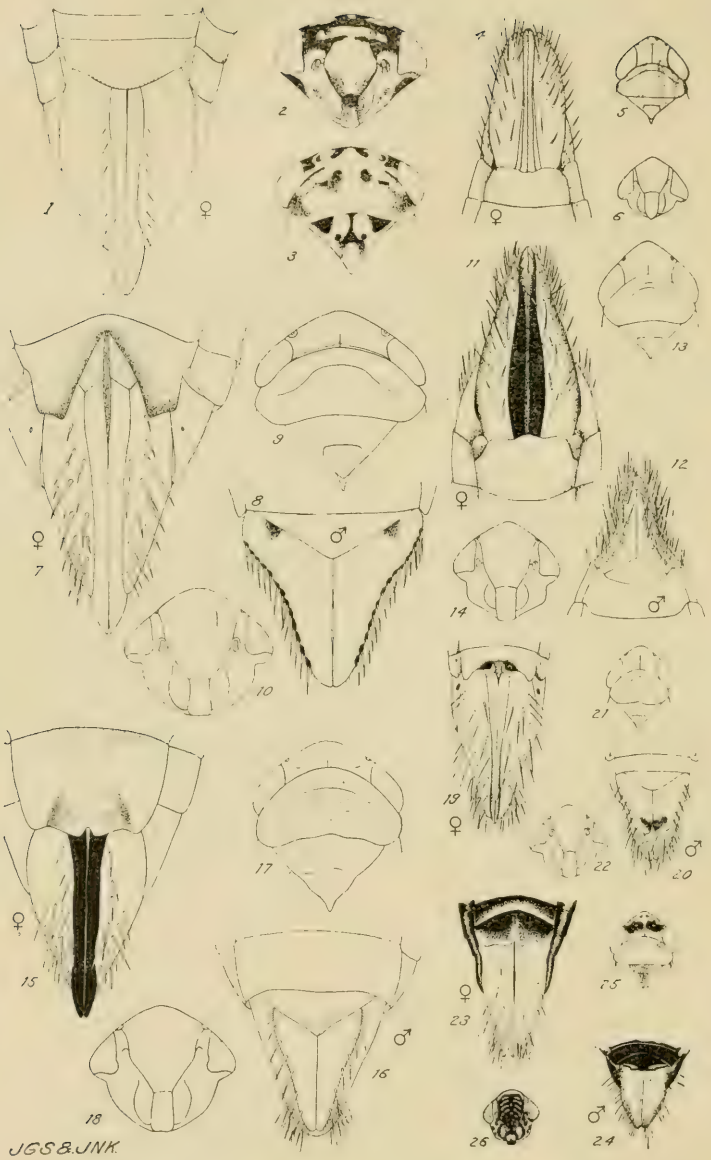
The figures of the vertex and face of species illustrated have been drawn to the same scale, while the genitalia have been drawn to the same scale, although more highly magnified.

Plate VIII.

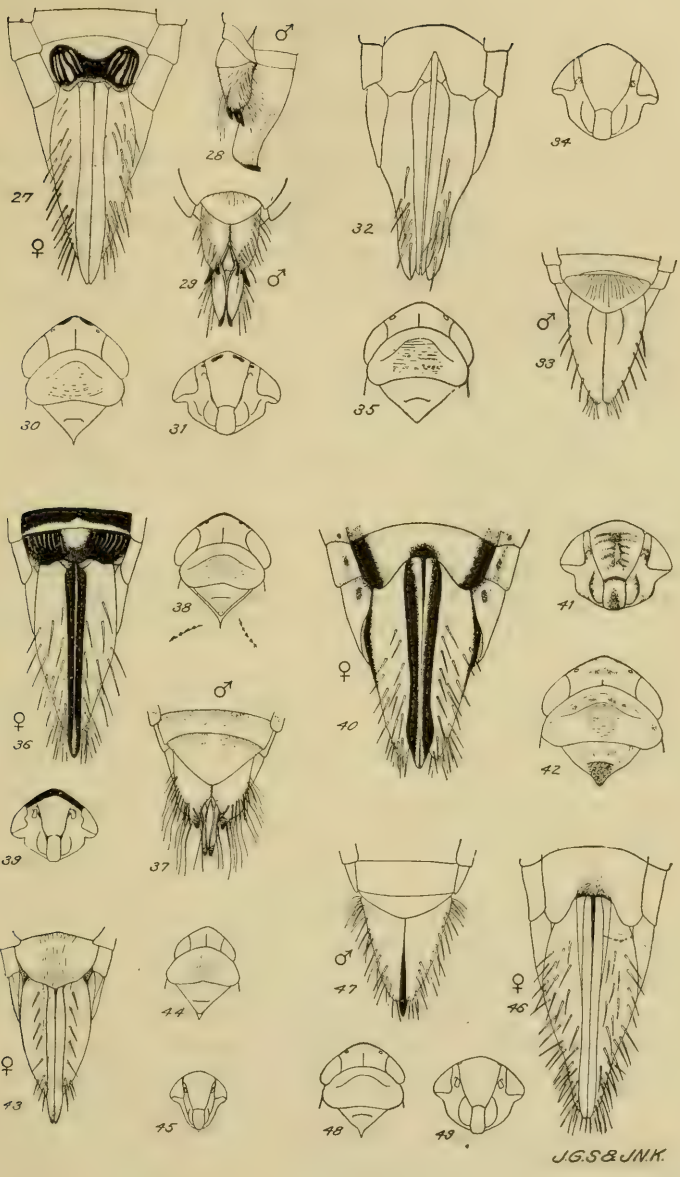
Idiocerus subnitens.....Figs. 1, 2 and 3.
Deltocephalus luteocephalus....Figs. 19, 20, 21 and 22.
Deltocephalus nigriventer.....Figs. 23, 24, 25 and 26.
Deltocephalus fumidus.....Figs. 11, 12, 13 and 14.
Deltocephalus concinnus.....Figs. 4, 5 and 6.
Euscelis deceptus.....Figs. 40, 41 and 42.
Phlepsius umbrosus.....Figs. 15, 16, 17 and 18.
Phlepsius bifidus.....Figs. 7, 8, 9 and 10.

Plate IX.

Thamnotettix stramineus.....Figs. 27, 28, 29, 30 and 31.
Thamnotettix mellus.....Figs. 46, 47, 48 and 49.
Thamnotettix vittipennis.....Figs. 36, 37, 38 and 39.
Chlorotettix borealis.....Figs. 32, 33, 34 and 35.
Empoa aureotecta.....Figs. 43, 44 and 45.



J. G. Sanders and D. M. DeLong.



J. G. Sanders and D. M. DeLong.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

New York Meeting.

The Eleventh Annual Meeting of the Entomological Society of America was called to order by First Vice-President E. P. Felt, in Room 411 of Teachers' College, Columbia University, New York City, at 2 P. M., December 26, 1916. After alluding to the death of the Society's President, F. M. Webster, which occurred on January 3, 1916, Dr. Felt appointed the usual committees, as follows:

Auditing—C. W. JOHNSON, WM. A. RILEY.

Resolutions—P. P. CALVERT, JAS. S. HINE.

Nominations—HENRY SKINNER, A. P. MORSE, J. C. BRADLEY.

The following papers were then read:

Life-histories and Habits of Gerridæ.....J. R. DE LA TORRE BUENO
Notes on the Habits and Immature Stages of Cyrtidæ...J. L. KING
Distribution of the Ohio Broods of Periodical Cicada with Reference to soil.....H. A. GOSSARD
Insect Collecting in Cameroon, West Africa.....REV. A. I. GOOD
Recent Observations and Theories Concerning the Origin of Social Habits among Vespidæ.....DR. J. BECQUAERT
The Phyletic Value of Ontogenetic Characters in the Elateridæ, J. A. HYSLOP
Biological Notes on Miris dolobrata.....HERBERT OSBORN
The Malpighian Vessels of the Alder Flea-beetle, WILLIAM COLCORD WOODS

At 5:15 the Society adjourned until the next morning, about 90 members having been in attendance.

December 27, 1916. The morning session was called to order at 9:30 by A. P. Morse, in the temporary absence of the First Vice-President. The following papers were read:

Some Recent Advances in Mosquito Work in New Jersey, THOS. J. HEADLEE
Studies on Coccobacillus acridiorum d'Herelle, and on Certain Intestinal Organisms of Locusts, E. MELVILLE DU PORTE AND J. VANDERLECK
Studies of Hypoderma lineatum and bovis.....SEYMOUR HADWEN

The time having arrived for the annual business session, the Executive Committee presented the reports of the Secretary, the Treasurer, the Managing Editor of the ANNALS, and of the Thomas Say Foundation, as follows:

REPORT OF THE SECRETARY.

The following members have been elected since the last annual meeting:

On July 17, 1916:

Frederick McMahon Gaige
Walter Allen Price
Shirley Lowell Mason
Lewis G. Gentner

On August 20, 1916:

Gonzalo Martinez Fortun
Ernest Melville Du Porte
Walter Norton Hess
Emerson Liscum Diven

On December 26, 1916:

H. B. Parks
Maurice E. Hays
C. W. Collins
Ray T. Webber
Chester Ittner Bliss
Rudolf William Glaser
Albert I. Good
Howard L. Clark
Frank R. Cole
Ralph Robinson Parker
Dettmar Wentworth Jones
Edward Riley King
Everett Elmer Wehr
Paul Hugo Isidor Kahl
Kirby Lee Cockerham
W. B. Williams
Seymour Hadwen
Herbert B. Hungerford
Christian E. Olsen
Phares H. Hertzog
William Bernard Donohue
Wallace Larkin Chandler
George Felix Arnold
Max Kisliuk
J. A. Corcoran

Total, 33.

The following members have resigned:

H. H. Brehme
Geo. Franck
W. A. Hooker
R. N. Wilson

Total, 4.

The following have died:

Francis Marion Webster, *President*
A. J. Cook
J. B. Williams
Ignaz Matausch
R. M. Moore

Total, 5.

Dropped for non-payment of dues, 11 members. Net gain, 14.

No Fellows or Honorary Fellows were elected in the year.

On December 14, 1916, the total membership of the Society was 578. Some idea of the interest of the members may be gained from the following figures regarding the payment of dues.

Disregarding for the moment the foreign members, life members, and honorary fellows, there were 10 members who were paid in advance at least for 1917; 414 were paid up for 1916; 54 were paid up for 1915; while 37 were owing for more than two years. These last are liable to suspension, but it costs the Society nothing to carry them, as they do not receive the ANNALS while in arrears, and the Secretary is endeavoring to revive their interest.

The year just closing has been a trying one for many of our foreign members, and yet their interest has been manifested in a gratifying manner. Out of 54 classed as foreign members (and in this classification the Secretary has rather arbitrarily included Cuba, Porto Rico, and Hawaii with continental North America, and not as foreign territory), the number who have paid dues during the year is just one-half, or 27. Several of these are in the war, and one sent his communication from the trenches. Regarding the other foreign members, obvi-

ously our wisest policy is to continue to carry them on the books until peace returns and they have an opportunity to resume the payment of dues. We all hope that they will then rejoin us in active membership.

The membership on December 14, 1916, was in the following classes:

Honorary Fellows	7
Fellows	47
Life Members	4
Regular Members	520
Total	578

Add 33 new members just voted in and our present membership is raised to 611.

TREASURER'S REPORT.

RECEIVED:

Balance last Treasurer's Report (ANNALS, March, 1916, p. 108) $110.36, less $12 outstanding check for clerical work for retiring Treasurer	$ 98.36	
Dues from members	930.44	
From Herbert Osborn, Managing Editor	354.33	
Interest on permanent Funds, January and July, 1916	10.29	
Interest on current balance	3.88	
Exchange	.26	
Total	$1,397.56	

PAID OUT:

Printing five numbers of ANNALS	$1,141.65	
Engraving for ANNALS	30.40	
To Herbert Osborn, for subscriptions	9.00	
Refunded to N. K. Jardine	3.33	
Thomas Say Foundation, preliminary expenses	40.00	
Printing for Secretary's office	30.00	
Stamped envelopes	39.08	
Clerical assistance	41.00	
Badges for annual meeting	11.00	
Express and stationery	2.99	
Interest on permanent funds, redeposited	10.29	
Balance on hand, December 14, 1916	38.82	
Total		$1,397.56

CONDITION OF PERMANENT FUNDS.

On deposit in Cleveland Trust Co., January 1, 1916:		
Four life memberships	$200.00	
Samuel Hubbard Scudder Fund	35.00	
Accumulated Interest	17.19	
Total		$252.19
Interest added to deposit:		
January 1, 1916	$ 5.15	
July 1, 1916	5.14	
Total		10.29
Total on Deposit December 14, 1916		$262.48

In accordance with previous action of the Executive Committee, enough of the accumulated interest will be added to the Samuel Hubbard Scudder Fund to bring it up to Fifty Dollars; this leaves the remainder of the interest, which may be drawn for running expenses of the Society, at $12.48.

REPORT OF THE MANAGING EDITOR OF THE ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

It has been possible during the present year to slightly increase the size of the volume as compared with the preceding year and the income which seems to be assured for the coming year will enable us to maintain the JOURNAL on the present basis.

The receipts and expenditures may be summarized as follows:

RECEIPTS.

Subscription account	$234.50
Sale of back numbers	150.32
Sale of reprints	34.80
Total Receipts	$419.62

DISBURSEMENTS.

Stamps, post office charges	$ 27.90
Stenographic help and labor	26.50
Engraving	10.89
Balance to Treasurer	354.33
Total Disbursements	$419.62

The appeal made to the members in regard to filling out their back sets seems to have been effective in a number of cases, as a larger number of back numbers were sold during the past year than in either of the two preceding years. We desire to express our appreciation for this assistance and especially for the securing of Library subscriptions which are ordinarily to be considered as continuations which will be of advantage to the publication in the future.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

REPORT OF THE THOMAS SAY FOUNDATION.

Of the six members of the Foundation appointed at the last annual meeting, Dr. Calvert resigned, and the Executive Committee by mail ballot, appointed J. M. Aldrich as editor, leaving the Foundation temporarily with only five members.

A meeting of the Foundation was called and convened at West LaFayette, Indiana, on September 11 and 12, 1916, at which were present A. D. MacGillivray, E. B. Williamson and J. M. Aldrich, a majority of the members. At this meeting J. M. Aldrich proposed that the Foundation print as its first volume his completed manuscript on "Sarcophaga and Allies in North America." On calculating the probable expense, the members believed that they were justified in going forward, and accepted the work as the first volume of the Foundation. Specifications were drawn up and bids obtained, and a contract let to the Murphey-Bivins Co., LaFayette, Indiana.

Arrangements were also made for the circulation of another appeal for ten-dollar advance subscriptions in the same envelope with the announcement of the coming meeting of the Entomological Society of America.

After the meeting, the printing of the book was completed according to contract, and subscribers have already received their copies.

A balance of $40.88 in the appropriation for preliminary expenses (ANNALS, March, 1916, p. 112) was drawn upon as follows:

Medallion of Say for frontispiece	$6.50
Printing appeal for subscriptions	6.50
Engraving 16 plates at $1.60	25.60
Greek characters and composition	1.40
Total	$40.00

The cost of printing an edition of 1000 and binding 200 is in all $456.00 in addition to the items mentioned above. This amount is due January 1. At the time of writing the funds in hand are somewhat over $300; the balance is arranged for temporarily, but will soon be made up from sales.

Respectfully submitted,

J. M. ALDRICH, *Editor.*

The Auditing Committee submitted the following report, which was on motion accepted:

"We have examined the accounts of J. M. Aldrich, Secretary and Treasurer, for the year ending December 14, 1916, and the accounts of Herbert Osborn, Managing Editor of the ANNALS, for the year ending December 1, 1916, compared the vouchers, and find them correct.

(Signed) CHAS. W. JOHNSON,
WM. A. RILEY.
Auditing Committee."

The Executive Committee further reported that they had appointed the following members of the Editorial Board of the ANNALS to take the place of Messrs. Kellogg, Howard and Wheeler, whose terms have expired:

T. D. A. COCKERELL, WM. A. RILEY, L. O. HOWARD.

Also that they had appointed the following members on the Thomas Say Foundation, in pursuance of the Constitutional provisions adopted since the last appointments a year ago:

Members for two years—NATHAN BANKS, A. D. MACGILLIVRAY.

Members for one year—MORGAN HEBARD, E. B. WILLIAMSON.

Editor—J. M. ALDRICH.

Treasurer—E. D. BALL.

The Committee further reported, in the case of a certain member whose commercial efforts were open to criticism, and were apparently aided by his advertising himself as a member of this Society, that the Secretary is instructed to request him to resign; if he does not do so, the Secretary is instructed to drop his name from the books and publish a statement of the facts in the ANNALS.

The Committee on Resolutions submitted the following report, which was on motion adopted:

"The Entomological Society of America desires to record its hearty appreciation of the action of the authorities of Columbia University and of Teachers' College in placing rooms and other facilities at the disposal of the Society for the purposes of the Annual Meeting.

The Society also thankfully acknowledges the courtesies it has received and is about to experience this evening from the American Museum of Natural History and from the Entomological Societies of New York and Brooklyn. (Signed) PHILIP P. CALVERT,
JAS. S. HINE,
Committee."

The Nominating Committee submitted the following report:

"The Nominating Committee nominate the following officers for the coming year:

President—LAWRENCE BRUNER.
First Vice-President—E. M. WALKER.
Second Vice-President—H. C. FALL.
Secretary-Treasurer—J. M. ALDRICH.
Executive Committee—E. B. WILLIAMSON, A. D. HOPKINS, W. J. HOLLAND, E. D. BALL, C. W. JOHNSON.

Respectfully submitted,
(Signed), HENRY SKINNER,
A. P. MORSE,
J. CHESTER BRADLEY,
Committee."

On motion, the Secretary was instructed to cast the ballot of the Society for the officers; which being done, they were duly declared elected.

Dr. Skinner moved that in the opinion of the Society, in taxonomic work a single type should be used, and that we recommend this policy. The motion being seconded, Professor Riley moved to refer it to the Committee on Nomenclature with instructions to report, which was carried.

Professor Riley moved that it be the sense of the meeting that papers should be limited to ten minutes. Dr. Headlee moved to leave the matter to the Secretary, which was carried.

No further business appearing, at 12 M. the Society adjourned until afternoon.

December 27, 1916, 2 P. M. The Society was called to order by Vice-President Felt, and the program of papers was continued, as follows:

Some Modifications in the Legs of Insects,
A. PETERSON AND A. D. MACGILLIVRAY
The Morphology of a Lepidopterous Head.....EDNA MOSHER
The Genus Erax in North America.....JAS. S. HINE
Entomology at the National Museum*.....T. D. A. COCKERELL

* Published in *Entomological News*, xxviii, p. 55, Feb., 1917.

Following Professor Cockerell's paper, it was moved and carried that a committee be appointed by the Executive Committee to promote the adequate development of the insect collections of the National Museum. Vice-President Felt stated that the committee would be announced at the evening session. The reading of papers continued, as follows:

Entomological Charts.....Z. P. Metcalf
A Guide to a Laboratory Study of the Scale Insects....R. A. Cooley
The Food of Drosophila.....J. P. Baumberger
Observations on Grylloblatta campodeiformis.....C. Gordon Hewitt
Sarcophaga haemorrhoidalis Larvæ as Parasites of the Human Intestine.....L. Haseman

(On account of the absence of the authors, the last two were read by the Vice-President and the Secretary.)

At 5:10 P. M., the Society adjourned until evening.

At 6 P. M., in company with the Association of Economic Entomologists, in the rooms of the American Museum of Natural History, the society was entertained by the New York and Brooklyn Entomological Societies at a buffet supper; and at 7:30 P. M. reassembled in one of the lecture rooms of the Museum, where the Annual Address of the Entomological Society of America was delivered by Professor T. D. A. Cockerell, on the subject, "Fossil Insects."

On calling the meeting to order, Vice-President Felt announced that the Executive Committee had selected the following committee to promote the adequate development of the insect collections of the National Museum:

T. D. A. Cockerell, Herbert Osborn, H. T. Fernald, Wm. M. Wheeler, Jas. G. Needham.

The program of the Annual Meeting having been completed, the Society adjourned *sine die*.

(Signed) J. M. Aldrich,
Secretary-Treasurer.

NOTICE.

In accordance with instructions given me by the Executive Committee at the Annual Meeting in New York City, on December 27, 1916, I have dropped the name of James Sinclair from the list of members of the Entomological Society of America.

J. M. Aldrich, *Secretary-Treasurer.*

West Lafayette, Ind., Feb. 9, 1917.

NOTICE TO MEMBERS AND CONTRIBUTORS.

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5 x 7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The Managing Editor is provided with the most recent address of all paid-up members on record in the Secretary's office for mailing the numbers of the Annals and members failing to receive their numbers should present their complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate.

Requests for information as to membership and the annual dues of members may be sent to the Secretary-Treasurer, J. M. ALDRICH, West Lafayette, Ind.

Communications relating to the ANNALS, and all orders for separate copies or reprints should be addressed to

HERBERT OSBORN, Managing Editor,
ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA,
State University, Columbus, Ohio.

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The regular annual subscription price for the ANNALS is in the United States, Cuba, Porto Rico, Hawaii and Mexico, $3.00; Canada, $3.50; other countries, $4.00. Checks, drafts or money order should be drawn payable to ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA, and addressed to HERBERT OSBORN, State University, Columbus, Ohio, U. S. A.

Volume X. Number 2.

ANNALS

OF

The Entomological Society of America

JUNE, 1917

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Founded 1906.

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A SYNOPSIS OF THE GENERA OF BEETLE MITES WITH SPECIAL REFERENCE TO THE NORTH AMERICAN FAUNA

By H. E. Ewing, Iowa State College, Ames, Iowa.

The beetle mites constitute, it is believed, a natural group of the order *Acarina* which, because of its close affinities with some of the other groups of mites, is rather hard to limit or define properly. As considered here, the group includes only those mites which possess, in addition to a hard, chitinous exoskeleton, a pair of modified setæ on the posterior dorsal aspect of the cephalothorax, known to specialists as the pseudostigmatic organs. Thus limited, the beetle mites have been recognized by some workers only as a family, by others as a superfamily, and by several of our foremost authorities as a sub-order. Michael in his treatise on the group[1] considered it as a family, the *Oribatidæ*, which he divided into seven subfamilies. Banks has considered the group as a superfamily, *Oribatoidea*, which formerly he divided into two families, *Hoplodermidæ* and *Oribatidæ*. Recently he has included the family *Labidostommatidæ*[2] also in the superfamily, but this family would not be included in the group as just defined by the writer. Oudemans regards[3] the group as one of the twelve of his subdivisions of the whole order, and gives to it the name of *Octostigmata*. The present writer in 1913, gave a classification of the Acarina[4] in which the tarso-

[1] Michael, A. D. Oribatidæ. Das Tierreich, Lieferung 3, 1898.
[2] Banks, N. The Acarina, or Mites. Report No. 108, U. S. Dept. Agric., 1915.
[3] Oudemans, A. C. A Short Survey of the More Important Families of Acari. Bul. Entom. Research, Vol. I, pp. 105-119, 1910.
[4] Ewing, H. E. New Acarina, Part I. Bull. Amer. Mus. Nat. Hist., Vol. XXXII, Art. V, pp. 93-121, 1913.

nemid mites were included with the beetle mites in a suborder called *Heterotracheata*. The beetle mites were divided into two sections under this suborder, *Ginglymosoma* and *Scleroderma*. The former section included the family *Hoplodermidæ* and the latter the families *Hypochthonidæ*, *Nothridæ*, and *Oribatidæ*. Berlese has in the last few years described some interesting new species, which show both the characters of the family *Hoplodermidæ* and also those of the families *Hypochthonidæ* and *Oribatidæ*. These should, I believe, be regarded as the direct descendents of the "connecting links" between these families, and their discovery must necessarily cause us to regard the *Hoplodermidæ* as being more closely bound to the other families than was formerly believed.

Considering the beetle mites as a phylogenetic unit, disregarding for the present their place in the order to which they belong, we find that they can be easily divided into four families already recognized by others. These four families I have divided into fourteen subfamilies, which are given with the families in the following key:

A KEY TO THE FAMILIES AND SUBFAMILIES OF THE BEETLE MITES.

A. Cephalothorax immovably united to abdomen; tracheæ usually present.
 B. Abdomen without dorsal grooves or sutures dividing it into parts; integument well chitinized.
 C. Abdomen provided with chitinous, wing-like expansions known as pteromorphæ, which usually are large and conspicuous, but which may be small and shelf-like.....**Oribatidæ**
 D. Cheliceræ swollen at their bases, styliform beyond, and ending in minute chelæ.....PELOPINÆ
 DD. Cheliceræ stout in the middle and with large chelæ....ORIBATINÆ
 CC. Abdomen without wing-like expansions known as pteromorphæ, even of the rudimentary, shelf-like type.....**Nothridæ**
 D. Cheliceræ rod-like, serrate toward their tips.....SERRARIINÆ
 DD. Cheliceræ not rod-like, chelate.
 E. Fourth pair of legs fitted for jumping.....ZETORCHESTINÆ
 EE. Fourth pair of legs not fitted for jumping.
 F. Lamellæ present, being either blade-like or in the form of straight chitinous ridges.
 G. Integument of dorsal surface of abdomen smooth, and without markings of any kind.....NOTASPIDINÆ
 GG. Integument with markings in the form of reticulations, tubercles, pits, sculpturings, or ridges.....TEGEOCRANINÆ
 FF. True lamellæ absent, but crooked or irregular ridges may be present.
 G. Some of the segments of the legs other than the femora swollen toward their distal ends and pedicellate proximally; legs slender.....DAMAEINÆ
 GG. None of the segments of the legs swollen and pedicellate except the femora.
 H. Ventral plate present, and usually containing the genital and anal apertures.....NOTHRINÆ
 HH. Ventral plate absent or rudimentary, and in no case inclosing genital and anal apertures.....LOHMANNINÆ

BB. Abdomen divided into areas dorsally by grooves or sutures making it appear segmented; integument usually poorly chitinized..**Hypochthonidæ**
C. Dorsal sutures of abdomen oblique; segments of legs inflated..TRIZETINÆ
CC. Dorsal sutures of abdomen transverse; segments of legs not inflated, HYPOCHTHONINÆ
AA. Cephalothorax hinged to abdomen; tracheæ absent.....**Hoplodermatidæ**
B. Abdomen divided into parts, as if segmented, by transverse grooves or sutures.....PROTOPLOPHORINÆ
BB. Abdomen not divided into parts, as if segmented, by transverse grooves or sutures.
C. Genital and anal openings situated in a large ventral plate which is anchylosed to dorsal plate.....MESOPLOPHORINÆ
CC. Genital and anal openings not situated in a large ventral plate, anchylosed to dorsal plate.....HOPLODERMATINÆ

These fourteen subfamilies contain many genera; especially is the subfamily *Oribatinæ* rich in genera. I have tried in the following pages to key out as many of the genera of the very large number proposed as appeared to be based upon good characters, and to be acceptable from the standpoint of nomenclature. However, a few genera appear to be good, that I have not been able to place in my keys, because of incomplete data on their generic characteristics. Many proposed genera will not be found in my keys. For various reasons some twenty-four of these have been excluded. Some were founded upon characters which I regard as purely specific; others are almost, if not exact, synonyms of older genera; others have names which are preoccupied; and yet others have been rejected for various reasons not here mentioned.

In the keys which follow, readers will find given with each genus the name of its author, the date of its establishment, and the name of its type species. Lack of space forbids a discussion of taxonomic points involved in the fixing of some of these types. In a few cases these will be given briefly in footnotes.

Family ORIBATIDÆ.

Key to the Genera of Subfamily Peloppinæ.

a. Abdomen with a shelf-like expansion extending forward from its anterior margin over the base of the cephalothorax.
b. No true lamellæ or translamella present.....**Pelops** Koch, 1835
[Type: *P. acromios* (Hermann)]
bb. Lamellæ, and frequently translamella present.....**Euplops** n. gen.
[Type: *Pelops uraceus* Koch]
aa. Abdomen without shelf-like expansion at its anterior margin,
Peloptulus[5] Berlese, 1908
[Type: *Pelops phaeonotus* Koch]

[5]Erected as a subgenus by Berlese.

Key to the Genera of Subfamily Oribatinæ.

a. Pteromorphæ attached, or apparently attached, to both cephalothorax and abdomen.....Tribe TANEOPTERA
b. Abdomen circular, or almost circular, in outline, and bearing large setæ, **Neogymnobates** n. gen.
[Type: *N. multipilosus* (Ewing)]
bb. Abdomen very long, subcylindrical; either hairless, or bearing small setæ.
c. Sides of cephalothorax and of abdomen somewhat swollen so that they are not parallel; femora II without expansions..**Gymnobates** Banks, 1902
[Type: *G. glaber* Banks]
cc. Sides of cephalothorax and abdomen subparallel; femora II with blade-like expansions.....**Oripoda** Banks and Pergande, 1910 (?)
[Type: *O. elongata* Banks and Pergande]
aa. Pteromorphæ attached to abdomen only.
b. Pteromorphæ not truncate in front; extending beyond the anterior margin of abdomen.....Tribe MACROPTERA
c. Pteromorphæ continuous with dorsal plate, not hinged to abdomen.
d. Pteromorphæ not extending downward from the place of their insertion, but projecting forward along the sides of cephalothorax, **Tenuiala** Ewing, 1913
[Type: *T. nuda* Ewing]
dd. Pteromorphæ extending downward as well as forward from the place of their insertion.....**Achipteria** Berlese, 1885
[Type: *Oribata nicoletii* Berlese]
cc. Pteromorphæ not continuous with dorsal plate, but hinged to it in such a manner that they can be folded down over the ventral surface of the body.....**Oribata**[6] Latreille, 1802
[Type: *Notaspis alatus* Hermann]
bb. Pteromorphæ usually truncate, not extending beyond the anterior margin of the abdomen.....Tribe BRACHYPTERA
c. Pteromorphæ united by a transverse shelf-like expansion from the anterior margin of abdomen.....**Jugatala** Ewing, 1913
[Type: *J. tuberosa* Ewing]
cc. Pteromorphæ not united by a shelf-like expansion from the abdomen.
d. Cephalothorax completely covered by a roof-like projection from its line of junction with the abdomen.....**Tegoribates** n. gen.
[Type: *T. subniger* Ewing]
dd. Cephalothorax not covered by any roof-like projection from the line of its junction with the abdomen.
e. Lamellæ attached to cephalothorax along a part, or the whole of their inner borders.
f. Either translamella present, or the lamellæ joined to each other in front.
g. Pteromorphæ not rudimentary (cusp-like, or shelf-like).
h. Integument rough, being either tuberculate or corrugated.
Eremaeozetes Berlese, 1913
[Type: *E. tuberculatus* Berlese]
hh. Integument not rough, although it may be finely punctate.
i. Translamella blade-like, or lamellæ joined in front.
j. Two pairs of lamellæ present, also tectopedia for legs II, **Sphaerozetes** Berlese, 1885
[Type: *Oribates orbicularis* Koch]
jj. A single pair of lamellæ present, tectopedia for second pair of legs absent.....**Podoribates** Berlese, 1908
[Type: *Oribates longipes* Berlese]
ii. Translamella a mere ridge.....**Protoribates** Berlese, 1908
[Type: *Oribates dentatus* Berlese]

[6]Oudemans and Banks use *Galumna* instead of *Oribata*, or *Oribates*, for this genus, holding that the *Notaspis alatus* Hermann is not a true *Oribata*. The writer prefers to follow Michael and others, believing it to belong to *Oribata*.

gg. Pteromorphæ rudimentary, shelf-like.....**Neoribatula** n. gen.
[Type: *N. brevisetosa* (Ewing)]

ff. Translamella absent, but lamellæ sometimes joined by a line (not by a ridge).

g. Tarsal claws monodactyle.

h. Integument rough, or pitted.....**Tegeozetes** Berlese, 1913
[Type: *T. tunicatus* Berlese]

hh. Integument smooth.....**Oribatodes** Banks, 1895
[Type: *O. mirabilis* Banks]

gg. Tarsal claws tridactyle.

h. Pteromorphæ rudimentary, or shelf-like, **Oributula** Berlese, 1896
[Type: *O. tibialis* (Nicolet)]

hh. Pteromorphæ not rudimentary.

i. Integument of dorsum smooth.....**Ceratozetes** Berlese, 1908
[Type: *Oribates gracilis* Michael]

ii. Integument rough, reticulate, or pitted.

j. No hairs on abdomen..... **Trachyoribates** Berlese, 1908
[Type: *Oribates ampulla* Berlese]

jj. Conspicuous hairs on abdomen...**Peloribates** Berlese, 1908
[Type: *Oribates peloptoides* Berlese]

ee. Lamellæ attached to cephalothorax at their bases only, very large.

f. Lamellæ entirely free from each other.....**Oribatella** Banks, 1895
[Type: *O. 4-dentata* Banks]

ff. Lamellæ united or joined together for much of their length,
Joelia Oudemans, 1906
[Type: *Oribates fiorii* Coggi]

Family Nothrinæ.

Subfamily Serrariinæ has but one Genus.....**Serrarius** Michael, 1883
[Type: *S. microcephalus* (Nicolet)]

Subfamily Zetorchestinæ has but one Genus.....**Zetorchestes** Berlese, 1888
[Type: *Z. micronychus* (Berlese)]

Key to the Genera of Subfamily Notaspidinæ.

a. Legs inserted well under the body; abdomen strongly arched,
Liacarus[7] Michael, 1898
[Type: *L. simile* (Nicolet)]

aa. Legs inserted at the edges of the body; abdomen not so strongly arched.

b. Lamellæ seldom more than half as long as the cephalothorax and being low blade-like, or ridge-like structures.

c. Lamellæ placed well toward the median plane and running together in front.....**Cultroribula** Berlese, 1908
[Type: *Notaspis juncta* Michael[8]]

cc. Lamellæ, which may be vestigial, placed more laterally, not running together in front, although they may be connected with a translamella,
Lucoppia Berlese, 1908
[Type: *Zetes lucorum* Koch]

bb. Lamellæ very long and narrow, about as long as the cephalothorax, lance-like and provided with cusps in front.

c. Lamellæ attached to cephalothorax for their whole length, except for the small cusp; abdomen somewhat truncate in front, **Conoppia** Berlese, 1908
[Type: *Oppia microptera* Berlese]

cc. Lamellæ attached to cephalothorax for about one-half their length; abdomen circular.....**Notaspis** Hermann, 1804
[Type: *N. bipilis*[9] Hermann]

[7] = *Liosoma*, which name was found to be preoccupied by Michael.

[8] This species was suggested by Michael in his "British Oribatidæ" as the type of *Notaspis* Hermann, but the type of *Notaspis* Hermann, was fixed by Nicolet in 1854, hence *Zetes lucorum* Koch is available as a type for *Lucoppia* Berlese.

[9] Not *Zetes lucorum* Koch.

Key to the Genera of Subfamily Tegeocraninæ.

a. Cephalothorax and abdomen joined above by a chitinous shield common to both.....**Scutovertex** Michael, 1879
[Type: *S. sculptus* Michael]

aa. Cephalothorax and abdomen not joined by a chitinous shield common to both.

b. Ungues tridactyle.

c. Tibiæ of legs not swollen or pedicellate.

d. Pseudostigmatic organs projecting out of the pseudostigmata.

e. Lamellæ very large, extending forward for almost the whole length of cephalothorax; translamella absent.....**Cepheus** Koch, 1835
[Type: *C. minutus*[10] Koch]

ee. Lamellæ low chitinous bars, united by a translamella,
Chaunoproctus Pearse, 1906
[Type: *C. cancellatus* Pearse]

dd. Pseudostigmatic organs sunk into the pseudostigmata,
Ommatocepheus Berlese, 1913
[Type: *Cepheus ocellatus* Michael]

cc. Tibiæ of the legs somewhat pedicellate and swollen,
Banksia[11] Voigts and Oudemans, 1905
[Type: *Notaspis tegeocranus* Hermann]

bb. Ungues monodactyle.

c. Lamellæ blade-like.

d. Cephalothorax separated from abdomen above by the unbroken anterior border of the latter.....**Tegeocranus** Nicolet, 1855
[Type: *T. coriaceus* (Koch)]

dd. Cephalothorax not completely demarcated from abdomen dorsally, because of the incomplete anterior border of the latter,
Tectocepheus Berlese, 1896
[Type: *T. velatus* (Michael)]

cc. Lamellæ low solid ridges.....**Carabodes** Koch, 1835
[Type: *C. femoralis* (Nicolet)]

Key to the Genera of Subfamily Damaeinæ.

a. Cephalothorax separated from abdomen dorsally by the complete anterior border of the latter.

b. Claws of all the tarsi monodactyle.

c. Abdomen circular or subcircular in outline; genital and anal openings usually close together.

d. Integument of dorsum of abdomen smooth.....**Damaeus** Koch, 1835
[Type: *D. geniculatus* (Linn.)]

dd. Integument of dorsum of abdomen rough, frequently reticulate.
Eremella Berlese, 1913
[Type: *E. vestita* Berlese]

cc. Abdomen oval, longer than broad; genital and anal openings usually separated from each other by a considerable distance.

d. Cheliceræ stout, strongly chelate.

e. Integument of dorsum smooth; larger forms..**Dameosoma** Berlese, 1892
[Type: *D. denticulatum*[12] (Canestrini, G. & R.)]

ee. Integument of dorsum rough (coarsely granular or tuberculate); smaller forms.....**Dameolus** Paoli, 1908
[Type: *D. asperatus* (Berlese)]

dd. Cheliceræ styliform.....**Suctobelba** Paoli, 1908
[Type: *S. trigona* (Michael)]

[10]Not *C. tegeocranus* (Hermann), or *C. latus* Koch.

[11]Name suggested in 1905 by Voights and Oudemans to replace *Kochia* Oudemans, 1900, which was found to be preoccupied. *Kochia* was suggested by Oudemans to replace *Cepheus* Koch, because the type of the old genus *Cepheus, C. latus* Koch, did not belong to the genus in question.

[12]Named by Paoli to replace the *D. concolor* of Berlese, which was found to be different from the *D. concolor* (Koch).

bb. Claws of the tarsi of the first three pairs of legs monodactyle, of the fourth pair tridactyle.....**Heterobelba** Berlese, 1913
[Type: *H. galerulata* Berlese]

bbb. Claws of all the tarsi tridactyle.

c. Pseudostigmatic organs foliaceous, or flabelliform,
Licneremaeus Paoli, 1908
[Type: *Notaspis licnophora* Michael]

cc. Pseudostigmatic organs not foliaceous or flabelliform.

d. Dorsal integument pitted or reticulate; second pair of legs about as long as others.

e. Tectopedia well developed; dorsal integument of abdomen pitted; hairs of abdomen long, flexible, pectinate,
Tricheremaeus Berlese, 1908
[Type: *Notaspis serrata* Michael]

ee. Tectopedia absent or rudimentary; dorsal integument of abdomen reticulate; hairs of abdomen simple.....**Micreremus** Berlese, 1908
[Type: *Eremaeus brevipes* Michael]

dd. Dorsal integument smooth; second pair of legs shorter than the others,
Heterodamaeus n. gen.
[Type: *Damaeus bicostatus* Koch]

aa. Border between cephalothorax and abdomen incomplete dorsally toward the median line so that the two parts of the body run together here,
Amerus Berlese, 1896
[Type: *A. troisi* (Berlese)]

Key to the Genera of Subfamily Nothrinæ.

a. Abdomen as a whole convex, or arched, above.

b. Dorsal plate of abdomen not fully chitinized; adults carrying cast nymphal skins arranged so as to form concentric areas at different levels,
Neoliodes[13] Berlese, 1888
[Type: *N. theleproctus* (Hermann)]

bb. Dorsal plate of abdomen fully chitinized; adults without cast nymphal skins.

c. Abdomen without lateral excretory tubes.

d. No seta-bearing tubercules on dorsum of abdomen,
Hermannia Nicolet, 1855
[Type: *H. picea* (Koch)]

dd. Mammæ-like, seta-bearing tubercles on dorsum of abdomen,
Masthermannia Berlese, 1913
[Type: *M. mammillaris* (Berlese)]

cc. Abdomen with a pair of lateral excretory tubes projecting some distance from the surface of the body wall.....**Hermanniella** Berlese, 1908
[Type: *H. granulata* (Nicolet)]

aa. Abdomen as a whole not convex above, but flat, concave, or undulating.

b. Abdomen oval in outline, except for the anterior border.

c. Tarsal claws monodactyle.....**Heminothrus**[14] Berlese, 1913
[Type: *Nothrus targionii* Berlese]

cc. Tarsal claws tridactyle.

d. Abdomen with a broad margin above differently marked from a central area.....**Cymbaeremaeus** Berlese, 1896
[Type: *Eremaeus cymba* Nicolet]

dd. Abdomen without a differentiated band or margin above,
Eremaeus Koch, 1842
[Type: *E. oblongus* Koch.]

bb. Abdomen rectangular, or trapezoidal in outline.

c. Abdomen with two large lateral lobes extending backward from its posterior margin.....**Uronothrus**[15] Berlese, 1913
[Type: *Nothrus segnus* (Hermann)]

[13] = *Liodes* Hermann, which name was found by Berlese to be preoccupied.
[14] Suggested as a subgenus by Berlese in 1913.
[15] Erected as a subgenus by Berlese.

cc. Abdomen without posterior lobes.
d. Abdomen with prominent marginal seta-bearing tubercles, sometimes only behind.....**Nothrus** Koch, 1835
[Type: *N. spiniger* Koch]
dd. Abdomen without seta-bearing tubercles.....**Gymnonothrus** n. gen.
[Type: *Nothrus sylvestris* Nicolet]

Key to the Genera of Subfamily Lohmanninæ.

a. Abdomen subcylindrical; tarsal claws either monodactyle or bidactyle.
b. Tarsal claws monodactyle.....**Lohmannia**[16] Michael, 1898
[Type: *L. paradoxa* (Haller)]
bb. Tarsal claws bidactyle.....**Eulohamannia**[17] Berlese, 1910
[Type: *E. ribagai* Berlese]
aa. Abdomen oval, not cylindrical; tarsal claws tridactyle.
b. Abdomen never divided by a transverse suture above; integument tuberculate; claws homodactyle.....**Tumidalvus**[18] Ewing, 1908
[Type: *T. americana* Ewing]
bb. Abdomen sometimes divided above by a transverse suture; integument not tuberculate; claws sometimes heterodactyle,
Trhypochthonius Berlese, 1904
[Type: *T. tectorum*, Berlese]

Family Hypochthonidæ.

Key to the Genera of Subfamily Hypochthoninæ.

a. Abdomen divided into two parts dorsally by a transverse suture.
b. Tarsal claws tridactyle; cephalothorax truncate in front,
Parhypochthonius Berlese, 1904
[Type: *P. aphidinus* Berlese]
bb. Tarsal claws mondactyle.
c. Abdomen spherical; dorsal surface tessellated,
Sphaerochthonius Berlese, 1910
[Type: *S. splendidus* (Berlese)]
cc. Abdomen not spherical; dorsal surface not tessellated.
d. Abdomen clothed with leaf-like setæ; shoulders each with a seta-bearing tubercle.....**Malacoangelia** Berlese, 1913
[Type: *M. remigera* Berlese]
dd. Abdomen clothed with setiform hairs; shoulders without seta-bearing tubercles.....**Hypochthonius** Koch, 1835
[Type: *H. rufulus* Koch]
aa. Abdomen divided dorsally into three or more parts by transverse sutures.
b. Abdomen clothed with moderate simple setæ.
c. Integument of dorsum of abdomen reticulate; body short,
Brachychthonius Berlese, 1910
[Type: *B. brevis* (Michael)]
cc. Integument of dorsum of abdomen smooth; body long,
Arthrochthonius n. gen.
[Type: *A. pallidulus* (Koch)]
bb. Abdomen bearing some large (enormous) pectinate, foliaceous, or plumose setæ.
c. Body clothed with large, broad, leaf-like or fan-like setæ,
Pterochthonius[19] Berlese, 1913
[Type: *P. angelus* Berlese]

[16] = the old *Michaelia*, which name was shown to be preoccupied by Michael.
[17] Erected as a subgenus by Berlese.
[18] Berlese claims, "Acari Nuovi," Manipulus VI, 1910, that my genus *Tumidalvus* is a synonym of his *Trhypochthonius*, 1904. I hold it to be distinct for reasons shown in the above key.
[19] Erected by Berlese as a subgenus.

cc. When leaf-like, or fan-like setæ present, they are confined to the abdomen.
d. Tarsi very long, slender; legs and cephalothorax clothed with simple setæ.....**Heterochthonius**[20] Berlese, 1910
[Type: *H. gibbus* Berlese]
dd. Tarsi short, stout; legs and cephalothorax clothed with pectinate setæ.....**Cosmochthonius** Berlese, 1910
[Type: *C. lanatus* (Michael)]
Subfamily Trizetinæ has but one Genus.....**Trizetes** Berlese, 1904
[Type: *T. pyramidalis* Berlese]

Family Hoplodermatidæ.

Key to the Genera of Subfamily Protoplophorinæ.

a. Claws of tarsi monodactyle.....**Protoplophora** Berlese, 1910
[Type: *P. palpalis* Berlese]
a. Claws of tarsi bidactyle, heterodactyle, and of enormous length,
Arthroplophora Berlese, 1910
[Type: *A. paradoxa* Berlese]
Subfamily Mesoplophorinæ has but one Genus.....**Mesoplophora** Berlese, 1904
[Type: *M. michaeliana* Berlese]

Key to the Genera of Subfamily Hoplodermatinæ.

a. Ungues monodactyle; anal and genital covers separate.
b. Cephalothorax with a median, dorsal carina.
c. Abdomen with a hood-like projection extending forward from its anterior margin.....**Steganacarus** n. gen.
[Type: *Hoplophora anomala* Berlese]
cc. Abdomen without hood-like projection extending forward from its anterior margin.
d. Abdomen as well as cephalothorax with a median carina above,
Tropacarus n. gen.
[Type: *Hoplophora carinatum* Koch]
dd. Abdomen without dorsal, median carina...**Hoploderma**[21] Michael, 1898
[Type: *H. magna* (Nicolet)]
bb. Cephalothorax without a median carina above.
c. Integument rough, pitted, or sculptured.....**Atropacarus** n. gen.
[Type: *Hoplophora stricula* Koch]
cc. Integument smooth, without pits or sculptures....**Ginglymacarus** n. gen.
[Type: *G. dasypus* (Duges)]
aa. Ungues tridactyle; anal and genital covers fused.
b. Integument rough, pitted, or sculptured.....**Euphthiracarus** n. gen.
[Type: *E. flavus* (Ewing)]
bb. Integument smooth, not pitted or sculptured....**Phthiracarus**[22] Perty, 1841
[Type: *Hoplophora ardua*[23] Koch]

[20]Although given by Berlese as a subgenus, I hold that the characters are good generic ones.

[21]Name suggested by Michael to replace Hoplophora, which was found to be preoccupied.

[22]=*Tritia* Berlese.

[23]Michael claims that Koch's *Hoplophora decumana* is only a synonym of *Hoploderma dasypus* Duges, hence is not included in *Phthiracarus*. I suggest *Hoplophora ardua* Koch as the type of *Phthiracarus*.

Descriptions of New Genera Here Proposed.

Genus **Eupelops**[24] n. gen.

With the characters of the subfamily **Pelopinæ.** A chitinous hood-like projection extends forward from the anterior margin of the abdomen, which may be narrow, or again quite broad, in the latter case frequently being quadrangular. This chitinous expansion usually unites the two pteromorphæ. Lamellæ present. Translamella present or absent.

Type species: *Pelops uraceus* Koch.

The type species for the genus *Pelops* Koch, *P. acromios* (Hermann), is without either lamellæ or translamella. This new genus is erected, therefore, to include many species which are like *P. acromios* (Hermann) in most respects, but do not have the cephalothorax nude above. Berlese's *Peloptulus*, 1908, includes species which are without the shelf-like projection from the anterior margin of abdomen. Three of our American species are included in *Eupelops: E. latipilosus* (Ewing), *E. minnesotensis* (Ewing), and *E. laticuspidatus* (Ewing).

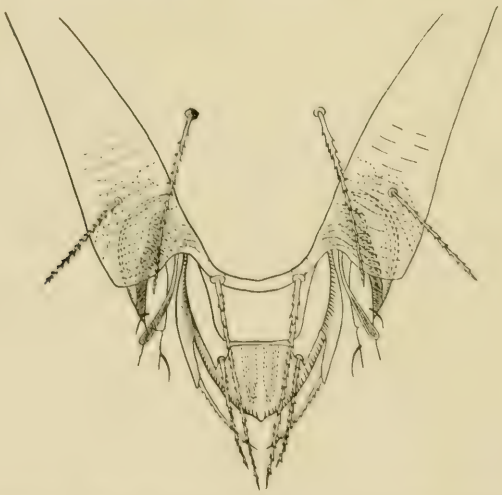


Fig. 1. *Neogymnobates multipilosa* (Ewing). Dorsal view of cephalothorax and anterior part of abdomen.

Genus **Neogymnobates**[25] n. gen.

With the characters of the subfamily **Oribatinæ**. Pteromorphæ attached to cephalothorax as well as to abdomen. Abdomen circular,

[24]From εὖ, good, well + *Pelops*.
[25]From νεος, new + *Gymnobates*.

or almost, in outline and bearing enormous setæ. Lamellæ present, blade-like. Translamella a chitinous ridge. A pair of lateral lamellæ present. Claws tridactyle.

Type species: *N. multipilosus* (Ewing). (See Fig. 1).

This genus is erected for a peculiar species described by the writer some years ago from specimens obtained in northern Illinois, not far from Chicago. At the time of collection I recognized that the species was quite different from other beetle mites, but hesitated in making it the type of a new genus. I regard this species, in a way, as a connecting link between the peculiar genus *Oripoda* Banks and Pergande and the other members of the subfamily *Oribatinæ*. It has the pteromorphæ of *Oripoda*, but the body of a true *Oribata*.

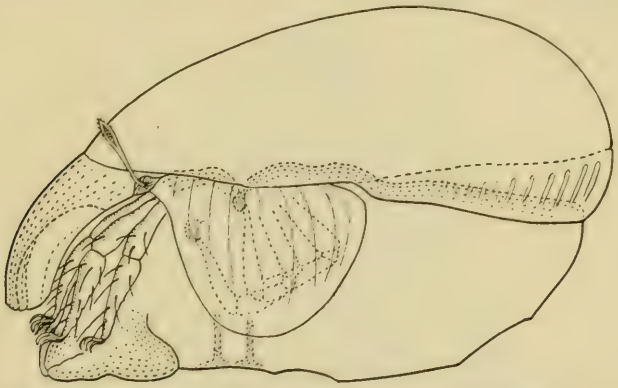


Fig. 2. *Tegoribates subniger* n. sp. Side view of individual with its legs flexed.

Genus **Tegoribates**[26] n. gen.

With the characters of the subfamily **Oribatinæ.** Pteromorphæ attached to abdomen only, truncate in front, not extending far beyond the anterior margin of abdomen, and not united by a transverse lamella. Cephalothorax completely covered by a roof-like projection which arises from the line of junction between the cephalothorax and abdomen and extends forward almost to the tip of the former.

Type species: *T. subniger* n. sp.[27] (See Fig. 2).

The large roof-like or hood-like projection above the cephalothorax in this genus makes it unique among the beetle-mites, and for that matter unique among all the mites in this respect. The nearest approach to this condition is found in the genus

[26]Meaning a covered *Oribates*.

[27]The descriptions of this species has been sent away for publication in Part II of my series on "New Acarina."

Joelia Oudemans, where the very large lamellæ are joined together in front at the median plane; however, in the case of *Joelia*, this junction is not complete so that no roof-like structure is formed. The genus *Tegoribates*, however, appears to be more closely related to some of the other genera than to *Joelia* Oudemans.

Genus **Neoribatula**[28] n. gen.

With the characters of the subfamily **Oribatinæ.** Pteromorphæ very small, rudimentary, attached to the abdomen only, truncate in front, not extending beyond the anterior margin of abdomen, and not united by a transverse lamella. Cephalothorax not covered by a roof-like projection. Lamellæ attached to cephalothorax along most of their inner margins. Translamella present.

Type species: *N. brevisetosa* (Ewing). (See Fig. 3).

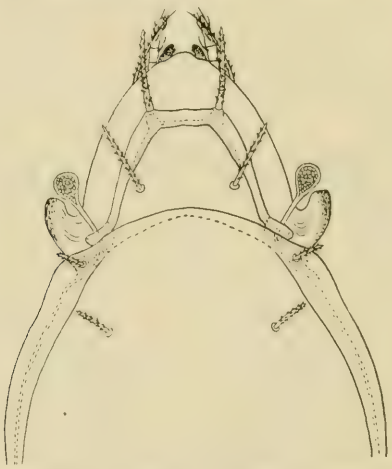


Fig. 3. *Neoribatula brevisetosa* (Ewing). Dorsal view of cephalothorax and anterior part of abdomen.

This genus is related to *Oribatodes* Banks and to *Oribatula* Berlese, but differs from both of these genera in having the translamella present and well developed.

Genus **Heterodamaeus**[29] n. gen.

With the characters of the subfamily **Damaeinæ.** Cephalothorax separated from abdomen dorsally by a complete anterior border of the latter. Tarsal claws all tridactyle. Pseudostigmatic organs not foliaceous or flabellate. Dorsal integument smooth. Second pair of legs shorter than others. Abdomen almost circular in outline, flat above.

Type species: *Damaeus bicosticus* Koch.

[28]From νεος, new + *Oribatula.*

[29]From ἕτερος, other than usual, different + *Damaeus.*

This genus is suggested to include some species of the old world and at least one from the new, *Damaeus magnisetosus* Ewing. Most of the species have the pseudostigmatic organs very long, the integument of the legs minutely tuberculate, while the tibiæ of the first pair of legs each bears above and distally a large tubercle from which a long tactile seta extends.

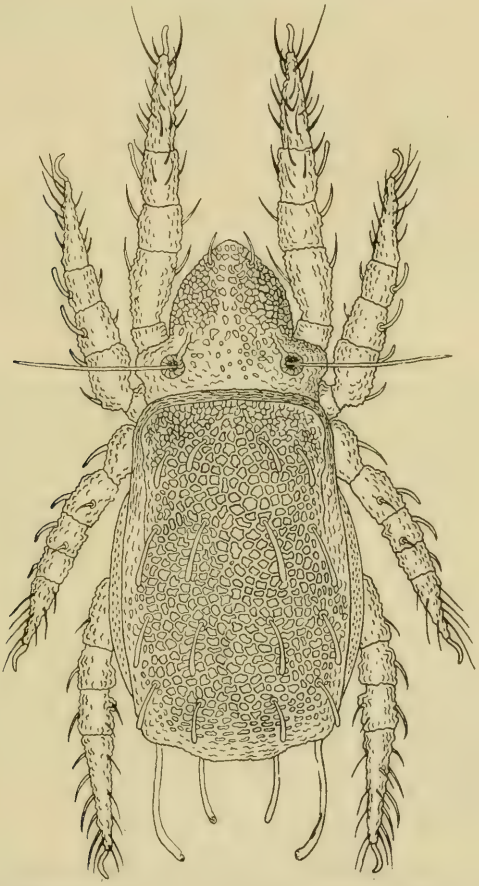


Fig. 4. *Nothrus sylvestris* Nicolet. Drawing made from a named specimen received from Michael.

Genus **Gymnonothrus**[30] n. gen.

With the characters of the subfamily **Nothrinæ.** Abdomen as a whole not convex above, but flat, concave, or undulating; rectangular or trapezoidal in outline. The abdomen is without large lobes behind, and also without seta-bearing tubercles.

Type species: *Nothrus sylvestris* Nicolet. (See Fig. 4).

[30]From γυμνός, naked + *Nothrus*.

This genus is erected to include the many nude species, which in the past have been placed in the genus *Nothrus*, but which differ markedly from the extreme and fantastic type species of that genus, *Nothrus spiniger* Koch.

Genus **Arthrochthonius**[31] n. gen.

With the characters of the subfamily **Hypochthoninæ.** Abdomen divided into three or more parts dorsally by transverse sutures, sides strongly depressed, shelf-like, clothed with moderate simple setæ. Integument of dorsum of abdomen smooth; body long, pyriform in outline. Cephalothorax without setæ above; pseudostigmatic organs very long; legs rather short; claws monodactyle.

Type species: *Hypochthonius pallidulus* Koch.

Erected to include many species related to those belonging to *Brachychthonius* Berlese, but having the body longer, the sides strongly depressed, and the integument smooth.

Genus **Steganacarus**[32] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Tarsal claws monodactyle; anal and genital covers separate. Cephalothorax provided with a median dorsal ridge or carina. Abdomen with a hood-like projection extending forward from its anterior margin.

Type species: *Hoplophora anomala* Berlese.

At least one of our North American species, *S. cucullatum* (Ewing), is included in this genus.

Genus **Tropacarus**[33] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Claws of tarsi monodactyle; anal and genital covers separate. Cephalothorax with a median carina above. Abdomen without hood-like projection extending forward from its anterior margin, but with a median carina above like the one on the cephalothorax.

Type species: *Hoplophora carinatum* Koch.

This genus is founded on this peculiar species of Koch's with the dorsal carina on both the abdomen and cephalothorax. I know of no American species which has these characteristics.

[31]From *ἄρθρου*, joint + *Chthonius*.
[32]From *στεγανός*, covered + *Acarus*.
[33]From *τρόπις*, keel + *Acarus*.

Genus **Atropacarus**[34] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Tarsal claws monodactyle; anal and genital covers separate. Cephalothorax without a median carina above. Integument rough, pitted, or sculptured.

Type species: *Hoplophora stricula* Koch.

One of our American species, *A. illinoiensis* (Ewing), known to be included in this new genus. There may be others.



Fig. 5. *Ginglymarcarus dasypus* (Duges). Drawing made from a named specimen received from Michael.

Genus **Ginglymacarus**[35] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Tarsal claws monodactyle; anal and genital covers separate. Cephalothorax without a median carina above. Integument smooth, without pits or sculptures.

Type species: *G. dasypus* (Duges). (See Fig. 5).

In this genus we find in our country at least two species besides the type species. They are *G. sphaerula* Banks and *G. lurida* Ewing. The genus will be found to include many foreign species.

[34]From a, not + τρόπις, keel + *Acarus*.
[35]From γίγγλυμος, hinge joint + *Acarus*.

Genus **Euphthiracarus**[36] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Ungues tridactyle; anal and genital covers fused. Integument rough, pitted or sculptured. (See Fig. 6).

Type species: *E. flavus* (Ewing).

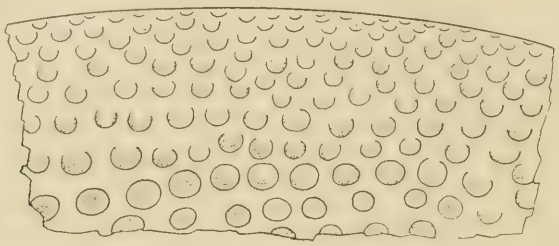


Fig. 6. *Euphthiracarus flavus* (Ewing). Side view of a section of the arched part of the abdomen to show nature of pitting.

This genus is suggested for the rough or pitted species of the old genus *Phthiracarus.* In this country I know of only one such species, the type. We have, however, about a dozen described species of the old genus *Phthiracarus.*

Acknowledgment.

Dr. J. W. Folsom, of the University of Illinois, aided the writer very materially in the preparation of this synopsis by offering him a laboratory in which to work and by helping secure some of the much needed literature.

[36]From εὖ, good, well + *Phthiracarus.*

SOME COLORADO SPECIES OF THE GENUS LACHNUS.

By C. P. Gillette.

Lachnus coloradensis, n. sp.

Adult Stem Mother.—General color black, with more or less rufous upon the head, thorax and legs; the anterior and nearly all of middle femora, the proximal portion of hind femora, and the basal portions of all tibiæ rusty brown, the hind tibiæ being black nearly to the base; all tibiæ black at extreme base; antennæ pale with distal ends of joints 3, 4 and 5 black. The black of the dorsum is mostly dull, but with polished lines running across between each two segments, and a larger polished area on joints 7 and 8. In some specimens there is somewhat of a rufous tinge over most of the dorsum; cornicles black, mammiform, terminating in a slightly projecting nipple; cauda scarcely apparent; vertex prominent and convex. Length of body 4.25; antenna 1.90. Joints of antenna: III, .50; IV, .26; V, .30; VI, .23; hind tibiæ, 3.10; beak attaining hind margin of third abdominal segment; sternum and first two abdominal segments rusty brown; head small, convex in front; one sensorium near distal ends of joints 3, 4 and 5, besides the permanent one on joint 5, and sometimes there are two on joint 4. (See Plate X, figures 1-3).

The young of the second generation are pale gray with dusky green upon dorsum of head and in the region of the cornicles, the thoracic segments being nearly white, and the abdomen dusky to brownish. (See figure 4.)

Apterous Viviparous Female.—General color black or blackish, somewhat shining, especially below; head, thorax, coxæ and basal portions of femora and tibiæ more or less rufous; antennæ pale with distal ends of joints black; terminal joint all black; shape of abdomen varying from broad oval to rather elongate. Length of antenna 2; joints proportioned as follows: 7 : 6 : 43 : 22 : 25 : 14; sensoria as in stem mother, except that there are usually two sensoria on joint 4; rostrum nearly attaining tip of abdomen; cornicles mammiform, small, about .40 across mammiform base; hind tibiæ very long and curved.

This form resembles the fundatrix so closely it was not thought necessary to draw it. Antenna shown in figure 5.

Winged Female of Second Generation.—Color rusty yellow to yellowish brown; cornicles, genital plates, mesosternum, coxæ, distal half of beak, joint 6 and distal ends of joints 3, 4 and 5 of antennæ, all of the tarsi, distal ends and very short proximal ends of all tibiæ (fully four-fifths of hind tibiæ), distal ends of all the femora, eyes and stigmas, black or blackish. The distal ends of middle and front femora may be only dusky; beak attaining 8th abdominal segment; dorsal surface slightly pulverulent; upon the pronotum there is a diagonal lateral line upon either side; there is a V-shaped white mark near the middle of the anterior margin and one near the posterior margin of the mesothorax and a white line near insertion of either front wing. The scutellum is more or less powdered, as is the metathorax, and transverse white dashes and lateral spots upon 3rd and 4th abdominal segments. See Plate X, figures 6 to 10.

Apterous Oviparous Female.—Prevailing color cinnamon brown to brownish black, shining, with head and pro- and meso-thorax a sordid pale yellowish green to light brown; beneath, pale greenish yellow, darker posteriorly and at lateral margins of abdomen; a heavy covering of white secretion upon the tergum and pleuræ of the abdomen back of the cornicles to the terminal segment, which is exposed; cornicles black, moderate in size of basal enlargement; antennæ with tips of joints 3, 4 and 5 and all of 6 black; beak nearly attaining the tip of the abdomen; form rather elongate; legs colored as in apterous viviparous female; hind tibiæ, with many small sensoria; hind legs very short; tibiæ but little swollen; length of body 3; antenna, 1.50; joints: III, .51; IV, .28; V, .29; VI, .20; hind tibiæ, 2.50. See figures 11-13.

Eggs.—They are deposited in single rows on the upper surface of the needles and are covered with a rather coarse, waxy material from the abdomen of the oviparous female. As soon as an egg is deposited, the female rubs her hind tarsi in the waxy secretion on her abdomen and then rubs them over the egg and continues this process till the latter is well covered with the short, broken bits of wax as shown in figure 14.

Alate Male.—Described from alcoholic material taken by Mr. L. C. Bragg from Engelmann spruce at Fort Collins, Colorado, November 9, 1906, along with the oviparous ♀ ♀.

Black parts, proportions of antennal segments, and cornicles as in alate viviparous ♀; length of body about 2.70; wing, 3.90; antenna, 1.45; hind tibia, 2.12; sensoria of antennæ numerous on joints 3 to 6, circular in form and varying much in size. The numbers upon the segments run about as follows: III, 18; IV, 14; V, 18; VI, aside from the rather scattered cluster of small sensoria about the permanent one, there is 1 or 2 on the basal half. See figure 15.

This is a common species upon Engelmann and blue spruces in Northern Colorado, which we have been taking for the past eight years. It is a bark feeder and has always been found by us attacking small limbs where the lice insert their beaks in the crevices of the bark. As in other species treated in this paper, the color markings of the young lice are very distinctive.

Our accessions records for this species are as follows:

Fundatrix	Ft. Collins, Colo.,	April 20, '08,	C. P. Gillette,	*Picea parryana*	
	" "	April 20, '08,	L. C. Bragg,	"	"
	" "	April 21, '08,	C. P. Gillette,	"	"
Alate and apterous viviparous females	" "	 '00,	C. P. Gillette,	"	"
	" "	May 4, '08,	C. P. Gillette,	"	"
	" "	May 12, '08,	C. P. Gillette	"	"
	" "	May 23, '08,	Miriam A. Palmer	"	"
	" "	May 25, '08,	C. P. Gillette,	"	"
	" "	June 6, '11,	L. C. Bragg,	"	"
	Ward, "	July 17, '09,	L. C. Bragg	"	"
	Tolland, "	July 25, '13,	Ellsworth Bethel,	englemanni	
Oviparous Female	Ft. Collins, "	Sept. 1, '06,	L. C. Bragg,	"	
	" "	Oct. 6, '09,	O. G. Babcock,	"	
	" "	Nov. 10, '14,	L. C. Bragg	"	
	" "	Nov. 14, '10,	L. C. Bragg,	"	
	" "	Nov. 9, '06,	L. C. Bragg,	"	
♂	" "	Nov. 9, '06,	L. C. Bragg,	*Picea parryana*	

***Lachnus palmeræ,** n. sp.

Stem Mother, First Instar.—General color ashy gray, due to a fine white powder which covers the body; eyes, tips of antennæ and beak, and the cornicles, black or blackish; a dusky to blackish transverse band, usually interrupted for some distance in the middle, upon the first abdominal segments; upon either side of the prothorax, an oblique, impressed dark line; and extending over the abdomen about six rows of small impressed dark spots. A very narrow median dorsal dark line is usually quite distinct and is due to the absence of the white powder. Antennæ, legs and body rather hairy; antennæ with four joints, the third being more than half of the antenna in length; fourth joint terminated by a short conical spur. As the lice grow in this instar the white powder increases in amount. At base of the spur is a single prominent sensorium. Length about 1.35.

The young lice, upon hatching, cluster on the bark of the twigs to insert their beaks and feed. See figure 16.

Described from specimens taken on a small Engelmann spruce on the college campus, March 17, 1910.

Adult Stem Mother.—The general color is a dark sordid brown, in some examples almost black; all of the lice conspicuously marked with gray or whitish lines and spots; a black transverse band, which is broken at the middle, extends across the first segment of the abdomen to the lateral margins; in front of this are black or dusky splashes upon the segments of the thorax, making two broken black bands extending to the head; the first and last joints of the antennæ, the distal ends of joints 4 and 5, the eyes, all of the tarsi, the coxæ, the knees, the distal ends of the tibiæ and their extreme bases, the cornicles and beak and the genital plates, black or blackish. From the head to the tip of the abdomen upon the dorsum is a narrow gray line on either side of which are broken transverse gray lines about one to each segment, and all about the same width as the median line, and in most instances, in two pieces, on either side of the median line. The head is light rusty brown, more or less covered with white powder; the antenna and the greater portion of the femora and tibiæ, are pale yellowish or sordid white in color. The cornicles are large, broad at the base, moderately elevated and mammiform in shape, and the beak reaches to the hind margin of the third segment of the abdomen; legs, antennæ and entire body, rather thickly set with slender hairs; head small, quite convex in front and usually distinctly bi-lobed; cauda not apparent. Length of body, 3.75 to 4 (balsam spec. 3 to 3.50) by 2.40 wide; length of antenna 1.30; joints: III, .45; IV, .20; V, .23; VI, (with spur) .17, with little variation. See figures 16a to 19.

Apterous Viviparous Female.—In general appearance and markings like the stem mother. No figures.

*I take pleasure in dedicating this species to Miss Miriam A. Palmer, not merely because she made the drawings for this and other aphid papers, but because she takes a keen and intelligent interest in everything scientific, and especially in the Aphides, and our friends, their enemies, the *Coccinellidæ.*

Young.—About one-third grown. Taken by the writer April 25, 1908. The meso- and meta-thorax are quite light and somewhat pinkish or flesh colored; the abdomen is dusky brown, but spotted with white pulverulence much after the pattern of the adult, and especially is this true of specimens about half grown; the head and abdomen are conspicuously darker than the thorax, usually almost black, with four conspicuous white blotches, two lateral, about midway of the abdomen, and two on the median line, one at the meta-thorax and the other at the extreme tip. The posterior half of the prothorax is also black except upon the middle portion. See figure 20. The beak of very young lice is nearly twice the length of the body. See figure 16.

Winged Female of Second Generation.—Described from specimens bred in the laboratory on sprigs of blue spruce, May 11, 1908.

General color of body, blackish; a rather conspicuous median white stripe begins on the vertex of the head and extends to the middle of the mesothorax. A continuation of this stripe appears as a white dash upon the middle of the scutellum and as white spots upon the median dorsal line of the abdomen. Upon either side of this row of dots upon the abdomen is another similar row, making three rows of white spots or dashes extending to the region of the cornicles. Back of the cornicles there is also more or less of a white powdery secretion appearing either as spots or transverse lines. On the scutellum the white may extend laterally so as to almost entirely cover this part. There is also some of this white powder along the lateral margins of the thorax beneath the wings, and upon the sides of the abdomen in front of the cornicles, and also behind and beneath these organs. The whole ventral surface is more or less spotted with white. Joints 1, 2 and 6 and the distal ends of joints 3, 4 and 5 of the antennæ, are black; all of the tarsi, the distal ends of all the femora and tibiæ, and the coxæ are black; the remaining parts of the legs and the antennæ are very pale yellow. The cornicles are very large and black; genital plates and eyes black; beak whitish to the middle, the distal one-half being black or blackish, and reaching to the eighth abdominal segment; wings of medium length, stigma long, black, narrow and parallel sided; stigmal vein straight; the whole surface of the body, including legs and antennæ, thickly set with fine hair; eyes very prominent; ocular tubercles very small; hind tibiæ black for fully one-half their length, and all of the tibiæ having a short black portion at the proximal end; beak surpassing cornicles. Sensoria rather indistinct and variable in number and distributed about as follows: On distal one-half of third joint, 3 to 5; fourth joint, 1 to 3; fifth joint, 2 to 3; cornicles about .30 high by .40 broad at base, mammiform. Length of antennæ about 1.30; joints I and II of antennæ together .24; III, .54; IV, .26; V, .27; VI, .18; length of body, 3.50; wing, 4.50; hind tibiæ, 2.50. The general color when placed in alcohol is a light yellowish brown. The third transverse vein with its branches is much more slender than the first and second stigmal veins. See figures 21-23.

Figure 22, Plate I, was drawn from an antenna plainly showing seven sensoria on Joint III, but 3 to 5 were all that could be seen in other examples.

Oviparous Female.—Differs from the stem ♀ in general appearance in being more slender in form, having the white markings much heavier, and especially in having the head and all the abdomen back of the cornicles, except the anal plate, white. The hind tibiæ are thickly set with sensoria throughout their length. Length of body 4; antenna, 1.15; ratio of joints beyond the second—30 : 14 : 16 : 13 (with spur). See figures 24 to 27.

The eggs are yellowish brown when laid and measure 1.30 millimeters in length. They soon turn black in the daylight and are deposited mostly on the bark of the twigs at the bases of the needles, but sometimes are placed upon the needles also. See figures 24 to 28.

Alate Male.—The males resembles the alate viviparous ♀, but are much smaller, about 2.30 long, and more slender; the white markings are lighter and the black markings upon the antennal segments are absent, or nearly so. Joints 3, 4 and 5 of the antenna have many tuberculate sensoria irregularly distributed throughout their lengths; about 50 may be counted on joint III, about 15 on IV, and about 6 on V. Ratio of joints beyond second about as follows: 20 : 10 : 12 : 7 (with spur).

Described from examples taken on blue spruce, Ft. Collins, Colo., October 14, 1910, by L. C. Bragg, and from *Picea Engelmanni*, Fort Collins, 10-6, '09, by O. G. Babcock. See figures 29 and 30.

This is a very common species on the blue spruce in the vicinity of Fort Collins, Colorado, and is altogether a bark feeder attacking the small limbs.

Our Collection records are as follows:

Young Fundatrix	Ft. Collins,	Colo.,	Mar. 16, '10,	M. A. Palmer,	*Picea engelmanni*
	"	"	April 21, '08,	C. P. Gillette,	" *parryana*
Adult Fundatrix	"	"	April 20, '08,	L. C. Bragg,	" "
	"	"	April 21, '08,	C. P. Gillette,	" "
	"	"	April 24, '08,	M. A. Palmer,	" "
	"	"	April 25, '08,	C. P. Gillette,	" "
Apterous and Alate Viviparous Females	"	"	May 4, '08,	C. P. Gillette,	" "
	"	"	May 5, '08,	C. P. Gillette,	" "
	"	"	May 11, '08,	C. P. Gillette,	" "
	"	"	May 12, '08,	C. P. Gillette,	" "
	"	"	May 12, '10,	L. C. Bragg,	" "
	"	"	May 16, '10,	L. C. Bragg,	" "
	"	"	May 18, '12,	L. C. Bragg,	" "
	"	"	May 20, '12,	L. C. Bragg,	" "
	"	"	June 2, '06,	L. C. Bragg,	" "
Oviparous Female	"	"	Oct. 6, '09,	O. G. Babcock,	" *englemanni*
	"	"	Nov. 11, '11,	L. C. Bragg,	" *parryana*
Male	"	"	Oct. 14, '10,	L. C. Bragg,	" "
	"	"	Oct. 17, '10,	L. C. Bragg,	" "
	"	"	Oct. 21, '09,	L. C. Bragg,	" *engelmanni*
	"	"	Oct. 22, '09,	L. C. Bragg,	" "

Lachnus braggii, n. sp.

Taken feeding upon the bark of the twigs of Colorado blue spruce, *Picea parryana*, only.

Stem Mother.—Almost completely covered with a white pulverluence, but over the dorsum there are many spots and transverse broken bands where the white powder is not present and where the dusky brown to black color of the body can be seen. The cornicles are dark brown or blackish in color, quite small, and not very much elevated above the surface. The legs except the tips of the tibiæ and the tarsi; and the antennæ, except the extreme tips, are light amber in color. The eyes and genital plates are black, and the ventral surface of the body is covered with a light gray pulverulence. Joint 6 and distal end of 5 of the antenna, black or blackish; length of body from 3.20 to 3.70; width 2.40 to 2.50; length of antennal joints: III, .40; IV, .17; V, .21; VI, .17; whole length, 1.10; joints 4, 5 and 6 usually with one sensorium each besides the permanent ones on 5 and 6. When placed in balsam, there is a broken line of black extending from the prothorax to the first segment of the abdomen on either side of the median line. The two lines are made by a pair of black blotches upon the dorsum of each thoracic segment; a row of small black dots lies outside of these near each margin. The body is covered with a very fine, but rather long, pubescence which occurs also upon the joints of the antennæ and upon the legs. The length of the hind tibiæ is 1.60 to 1.70; beak short, but little surpassing the hind coxæ. See Plate XI, figures 1 to 4.

Apterous Viviparous Female, Second Generation.—Body covered with white pulverulence as in case of the stem mother; color also the same throughout. Length of body 3.75; width 2.40; antennal joints: III, .46; IV, .18; V, .23; VI, .17; length of antenna, 1.17; cauda appearing as a short broad lobe, convex on the posterior margin, and slightly upturned; beak just surpassing the 2d coxæ; head very small, quite convex on the frontal margin, not bi-lobed; sensoria of antenna rather indistinct and about as follows: III, 0; IV, .1 or .2; V, .2; VI, with terminal cluster. See figure 5.

Young of Third Generation, before first moult, pale amber in color, with a light covering of white pulverulence, and the head rather conspicuously dark dusky brown. Down the dorsum is a double row of small naked spots that appear a little darker than the general surface. The cornicles appear as little black dots and the genital plates and tarsi are dusky brown. See figure 6.

Winged Female, Third Generation.—Reared in the laboratory from the same colony from which the stem mother was described.

The ground color is pale to dark yellowish brown, or, in light examples, a sordid white. Head and thorax above, blackish or dark chocolate brown, rather heavily powdered with white; eyes and cornicles black, as are also the tarsi, and distal ends of all the tibiæ, the genital plates, the stigma of the wings, the last joint of the antennæ and very short distal rings upon joints 3, 4 and 5. The abdomen may be almost entirely white, due to the white powder which covers the body, or there may be very distinct white transverse bands separated by a somewhat

darker portion which exposes the yellowish color of the abdomen beneath. On the under surface, the color is pale yellowish, more or less heavily powdered everywhere with white. The distal ends of the femora are dusky brown, or, in some specimens, almost black, especially the hind pair. The cornicles are very small as in the apterous stem mother; hind tibiæ short, stigma of wing long and narrow and almost parallel sided; length of body, 2.75; length of wing, 3.70; cauda short and very broad and oval on the posterior margin, which is black; antenna, 1.14; hind tibia, 1.60; beak, 1.54; cornicles mammiform, smaller than in *palmeræ*, about .11 high by .14 broad at the base; joints of antennæ about as follows: III, .44; IV, .19; V, .23; VI, .17; sensoria of the antennæ about as follows: III, 1; IV, 1; V, 2; VI, usually 1 or 2 small ones a little below the large terminal one; entire surface of the body, including antennæ, thickly set with long delicate hairs. See figures 7 to 10.

In alcohol, the general color is pale yellow and the dorsum of the abdomen is sprinkled with black specks and dashes.

Oviparous Female.—General body color pale yellow, covered everywhere with white powder; form rather robust; thorax and segments 3 and 4 of the abdomen with broken transverse bands or dashes, and a rather distinct transverse blackish band upon the fifth segment of the abdomen between the cornicles; upon the other segments black patches only are to be found. The cornicles are black, as are the eyes, distal 2 or 3 joints of the antennæ, the tarsi, the extreme tip of the abdomen above, the hind tibiæ and the distal ends of all the femora and the middle and anterior tibiæ and coxæ; cornicles rather small. When the white powder is removed, the head and two anterior segments of the thorax are dark brown in color; length of body, 3.45; width, 2; length of antenna, 1.57; joints of antenna: III, .37; IV, .17; V, .20; VI, including unguis, .17; sensoria as follows: III, none or 1 near distal end; IV, 1 or 2; V, 1 or 2; hind tibiæ with numerous sensoria distributed throughout their length. See figures 11 to 13.

Egg.—1.25 long and .55 in diameter. See figure 14.

Alate Male.—General body color black or blackish; the body more or less covered with white pulverulence, and, on the ventral surface, green when the powder is removed; eyes, antennæ, cornicles, tarsi, distal ends of tibiæ and the greater portion of the femora black; beak reaching the tip of the abdomen; wings with costal margin and stigma blackish, the latter being rather long and broad; stigmal vein heavier than the cross veins of the wings; first and second transverse nerves moderately strong; the cubital vein with its forks very slender and scarcely visible in places; length of body, 2.20; antenna, 1.34; hind tibia, 1.46; wing, 4; antennal joints 3, 4 and 5 with many tuberculate sensoria; III about 30; IV, about 14; V, about 8. The hairs upon the legs and antennæ are rather long, thickly set and very slender. See figures 15 and 16.

This species was first discovered by Mr. Bragg upon Colorado blue spruce in Fort Collins. We have not been able to find it upon other trees. Its rather close ally seems to be *L. palmeræ*, but that species is very common and in no instance

have we found it heavily covered with the white secretion. It appears like a rusty brown or black louse on the twigs, while this one appears like a very light gray or white louse.

Our collection records are as follows:

Fundatrix	Ft. Collins,	Colo.,	April 13, '08, L. C. Bragg,	*Picea parryana*	
	"	"	April 21, '08, C. P. Gillette,	"	"
	"	"	April 28, '08, L. C. Bragg,	"	"
Alate and apterous viviparous females	"	"	April 22, '08, C. P. Gillette,	"	"
	"	"	April 25, '08, C. P. Gillette,	"	"
	"	"	May 14, '08, C. P. Gillette,	"	"
	"	"	May 19, '10, L. C. Bragg,	"	"
	"	"	May 21, '15, L. C. Bragg,	"	"
	"	"	June 12, '14, L. C. Bragg,	"	"
Ovip. ♀	"	"	Oct. 15, '10, L. C. Bragg,	"	"
	Boulder,	"	Oct. 23, '09, L. C. Bragg,	"	"
Male	Ft. Collins,	"	Oct. 15, '10, L. C. Bragg,	"	"

Lachnus tomentosus (De Geer).

Examples of what seems to be this species were taken by the writer from needles of *Pinus radiata*, standing on the campus of the University of California, August 8, 1915, where they were very abundant. The examples taken agree in nearly every respect with the excellent description and figures of this species given by G. Del Guercio in "Contribuzione Alla Conoscenza dei Lacnidi Italiani," 1909, p. 283.

Examples taken on *Pinus scopulorum* in Colorado and listed below, agree so closely with the European form I refrain from giving it even a varietal name.

I give below descriptions and figures made from freshly collected Colorado material. The sexual forms of this louse were found by the writer in very great abundance upon the trees of *Pinus scopulorum* in the City Park of Denver, during the month of October, 1916.

Young Stem Mother.—Specimen taken at Horsetooth Mountain, west of Fort Collins, as early as March 13, 1910. The lice were still hatching and had the habit of arranging themselves in single file, so close that they touched each other, along the needles. When first hatched, the color is dark olive-green with pale yellow legs and antennæ. After a few hours a slight grayish bloom covers the body, the legs and antennæ become considerably darker in color and the cornicles are each in a small dusky circular spot. One or two rows of small dark spots a little inside the lateral margin on either side, extend longitudinally over the abdomen. Beak not attaining tip of abdomen; length of body, 1 millimeter. See figure 17.

Adult Stem Mother.—Entirely cinereous in general color on account of a heavy flocculent secretion covering the body, legs and antennæ. The eyes, ends of the antennæ, cornicles and naked tarsi are deep black; body color, beneath the secretion, dark olive-green, legs dusky with tibiæ black tipped. Length of body 2.10; antennæ, 1; hind tibiæ, 1.30; beak but little surpassing hind coxæ; joints of antennæ: III, longest; IV and V, sub-equal; VI, with very short spur, a little shorter than V; permanent sensoria on joints V and VI only; body antennæ and legs rather sparsely set with long slender hairs. See figures 18 to 20.

Alate Viviparous Female.—Slender and powdery in appearance; length 2; antenna, 1.12; joints of antenna, III, .45; IV, .20; V, .18; VI (with spur), .15; sensoria on joint III usually very faint or appearing to be entirely absent, but as many as 3 weak sensoria found in some examples; hind tibia 1.40; beak barely reaching third coxæ. See figures 21 and 21b.

Apterous Oviparous Female.—Described from specimens taken upon the leaves of *Pinus scopulorum*, Boulder, Colorado, October 23, 1909.

The general color varies from a yellowish brown to a brownish black; the head and terminal joints of the abdomen and the small cornicles black, or blackish; the ventral surface of the abdomen and also the last two segments above, as well as below, covered with pulverulent secretion; antennæ dusky in proximal portion and becoming black towards the distal ends; eyes black; legs black except the basal portion of the middle tibiæ, and in some specimens the anterior tibiæ also; coxæ black; beak reaching the middle pair of coxæ; cornicles quite small, hardly broader than high; length of body, 2.71; length of antennæ, 1.14; joints of antennæ: III, .46; IV, .20; V, .25; VI, .17. The joints are rather slender and set with long slender hairs. Hind tibiæ, 1.75 and considerably swollen in the basal half, where there are numerous circular sensoria. Genital plates black, permanent sensoria only upon joints 5 and 6 of the antennæ. See figures 25 to 28.

Taken depositing eggs in longitudinal rows upon the pine needles. The eggs are covered with the cottony secretion from the bodies of the lice which is rubbed on by means of their hind feet. Figures 23 to 30.

Winged Male.—Body almost black in color, but rather heavily covered with pulverulent secretion, both above and below. The antennæ, legs, costal margin of wings, stigma, stigmatic vein and eyes black. The first and second cross veins are also rather conspicuously black. Second fork of cubital vein, at least in some wings, entirely wanting. Length of body, 2; antenna, 1.57; wing, 3.43; hind tibiæ, 1.60; beak surpassing the hind coxæ; joints of antennæ: III, .60; IV, .29; V, .31; VI, .2. Numerous tuberculate sensoria occur upon joints 3, 4 and 5; upon III, about 28; IV, 14; V, 6; second fork of cubital vein absent on all the wings of the five specimens examined.

The tarsi are very long in this species, the hind tarsus being nearly as long as joint 3 of the antenna. See figure 31.

This species seems very close to *L. pini-radiatae* Davidson.

Collection data as follows:

Fundatrix	Ft. Collins,	Colo.,	April 7, '10,	M. A. Palmer,	*Pinus scopulorum*
	"	"	May 28, '08,	L. C. Bragg,	" "
Alate and apterous viviparous females	Colo. Spr.,	"	June 22, '99,	L. C. Bragg,	" "
	Ft. Collins,	"	June 30, '15,	C. P. Gillette,	" "
	Livermore,	"	July 18, '16,	M. A. Palmer,	" "
Oviparous ♀	Ouray,	"	Sept. 27, '14,	C. P. Gillette,	" "
	Ft. Collins,	"	Oct. 13, '10,	L. C. Bragg,	" "
	Boulder,	"	Oct. 23, '09,	L. C. Bragg,	" "
	Ft. Collins,	"	Nov. 7, '09,	M. A. Palmer,	" "
	"	"	Nov. 25, '09,	M. A. Palmer,	" "
Male	Ouray,	"	Sept. 27, '14,	C. P. Gillette,	" "
	Ft. Collins,	"	Oct. 13, '10,	L. C. Bragg,	" "
	Boulder,	"	Oct. 23, '10,	L. C. Bragg,	" "
	Ft. Collins,	"	Nov. 7, '09,	M. A. Palmer,	" "

***Lachnus ponderosæ** Williams.

Stem Mother.—Described from two specimens taken among many second generation individuals on the bark of the smaller twigs of *Pinus ponderosa*. Specimens taken by Miss Miriam A. Palmer in the foothills west of Ft. Collins.

Ground color of adults golden brown, cornicles black with very large mammiform bases of the same color; powdery above and below; the markings not well defined as the specimens have been rubbed; distal ends of femora and proximal and distal ends of tibiæ black; hind tibiæ with only a small portion near the proximal end pale; beak attaining the tip of the abdomen; anal plates black; length of body 3; width 1.90; hind tibiæ 2. A rather robust species. No figures.

Apterous Female, Second Generation.—Taken April 30, 1910, along with the winged examples described below.

Ground color dark, golden brown; cornicles, tips of antennæ, distal ends of femora and tibiæ, tarsi, transverse patches on joints 1, 2, 7, 8 and 9 of the abdomen; joints 1, 2 and 6 and distal ends of joints 3, 4 and 5 of the antennæ black; lateral margins of the thorax, an irregular median patch on the first three joints of the abdomen and on either lateral one-third of joint 4 of the abdomen powdery white; also small white spots posterior to the cornicles on lateral margins of joints 6, 7 and 8. Length, 2.75; width, 1.50 to 1.75; antenna, 1.17; hind tibiæ, 2; joints of antenna in about the following ratios: 13 : 12 : 61 : 23 : 29 : 21 (with spur). The sensoria are not always easily seen, but in most examples they can be determined as follows: III, 1; IV, 1; V, 2; VI, with terminal or permanent sensoria only. It is not unusual to find two sensoria on joints III and IV and occasionally 3 or 4 may be found on joint III. See figures 32 to 35.

Alate Viviparous Female.—General color of the abdomen the same golden brown as in the stem female; head, thorax, cornicles and anal plate black; antennæ blackish; the basal portions of joints 3, 4 and 5 of the antennæ pale; stigma long, narrow, parallel sided, black and extending nearly one-half the distance from its distal extremity to base of wing; tibiæ with a pale ring near the proximal end; length of body 2.50; wing 4; hind tibiæ, 2.25; joint 3 of antenna as long as 4 and 5 together; 5 distinctly longer than 4; 6 with spur, not quite as long as 4; joint 3 with 4 to 6 large sensoria; joints 4 and 5 with two sensoria each.

Described from many specimens taken at different dates upon the twigs of yellow pine, *P. ponderosa*.

Supplementary description from a dozen fresh specimens just taken from pine twigs brought to the laboratory today, April 13, 1910.

Middle legs entirely black, except for a narrow light ring near the proximal ends of the tibiæ; hind tibiæ entirely black in some examples, others show the pale annulus; entire under surface powdered with white secretion; diagonal white lines more or less distinct upon the mesothorax, and there are four prominent transverse white bands, widest at the middle, upon the dorsum of the abdomen in front of the cornicles;

*Aphididæ of Nebraska, 1910, p. 22.

a spot between the cornicles, and a large transverse band back of the cornicles; sensoria of third joint of antenna four to six in number, and two each upon segments 4 and 5; beak extending nearly to the tip of the abdomen or surpassing it; tibiæ between 1.80 and 2.10. See figures 37 to 42.

Alate Male.—Described from a single specimen in balsam. Length of body, 1.40; antenna, 1; joints of antenna proportioned as follows: III, 26; IV, 15; V, 16; VI (with spur), 13; sensoria rather strongly tuberculate nearly circular and varying greatly in size occurring on all sides of the segments, very numerous on joint III; joint IV with 10 to 12; V, with 5 to 6; VI with 1 besides the terminal group; eyes very prominent; beak long, extending somewhat beyond the tip of the abdomen; hind tibia, 1.25; wing, 3.3;. See figure 40, Plate II.

Taken by Miss M. A. Palmer on *Pinus scopulorum*, Nov. 25, 1909, in the foothills, near Fort Collins.

For the original descriptions, see "The Aphididæ of Nebraska," Williams, in University Studies, Vol. X, No. 2, 1910.

Lachnus pini (Linn), as described by Kaltenbach and Koch, is very close to this species.

We have taken examples of this species, all from *Pinus ponderosa* as follows:

Young Stem Mothers.....	Ft. Collins,	Colo.,	Mar.	3, '10, C. N. Ainsley
Adult Stem Mothers.....	"	"	Mar.	19, '10, M. A. Palmer
Apterous and Alate Viviparous Females....	Boulder,	"	Aug.	7, '98, C. P. Gillette
	Ft. Collins,	"	April	8, '16, L. C. Bragg
	"	"	April	11, '10, M. A. Palmer
	" ft. hills	"	April	13, '09, M. A. Palmer
	"	"	April	23, '11, M. A. Palmer
	"	"	May	13, '10, M. A. Palmer
	Boulder,	"	May	31, '11, L. C. Bragg
	"	"	June	1, '11, L. C. Bragg
	"	"	June	1, '12, L. C. Bragg
	Ft. Collins,	"	June	4, '13, L. C. Bragg
	"	"	June	11, '16, L. C. Bragg
	Walsenburg,	"	June	15, '07, C. P. Gillette
	Boulder,	"	June	18, '09, L. C. Bragg
	Colo. Spr.,	"	June	20, '11, L. C. Bragg
	Boulder,	"	June	24, '13, L. C. Bragg
	Ft. Collins,	"	June	25, '11, M. A. Palmer
	Eldora,	"	June	25, '11, L. C. Bragg
	Boulder,	"	June	28, '06, L. C. Bragg
	Ft. Collins,	"	June	28, '16, L. C. Bragg
	Trinidad,	"	June	30, '10, B. G. D. Bishopp
	La Plata,	"	July	7, '98, C. P. Gillette
	Ft. Collins,	"	July	14, '16, M. A. Palmer
	Livermore,	"	July	18, '16, M. A. Palmer
	Ft. Collins,	"	Aug.	15, '16, M. A. Palmer
Oviparous Females and Males.....	Ft. Collins,	Colo.,	Nov.	23, '10, M. A. Palmer
	"	"	Nov.	25, '09, M. A. Palmer

EXPLANATION OF PLATES.

Plate X.

Lachnus coloradensis, n. sp. 1, adult fundatrix, × 7; 1a, cauda of fundatrix, × 40; 1b, cauda of fundatrix (side view); 1c, gonopophyses of apterous viviparous, × 70; 2, antenna of fundatrix, × 40; 3, cornicle of fundatrix; 4, young, second generation, one-third grown, × 7; 5 antenna of apterous viviparous, × 40; 6 alate viviparous, second generation, × 7; 7 cornicle of alate viviparous, × 40; 8, terminal three joints of the beak, × 40 (alate); 9, tarsal joints of alate viviparous, × 40; 10, antenna of alate viviparous, × 40; 11, oviparous female, × 7; 12, antenna of oviparous female, × 40; 13, tibia of oviparous female, × 23; 14, eggs laid on spruce needles, × 5; 15, antenna of male, × 40.

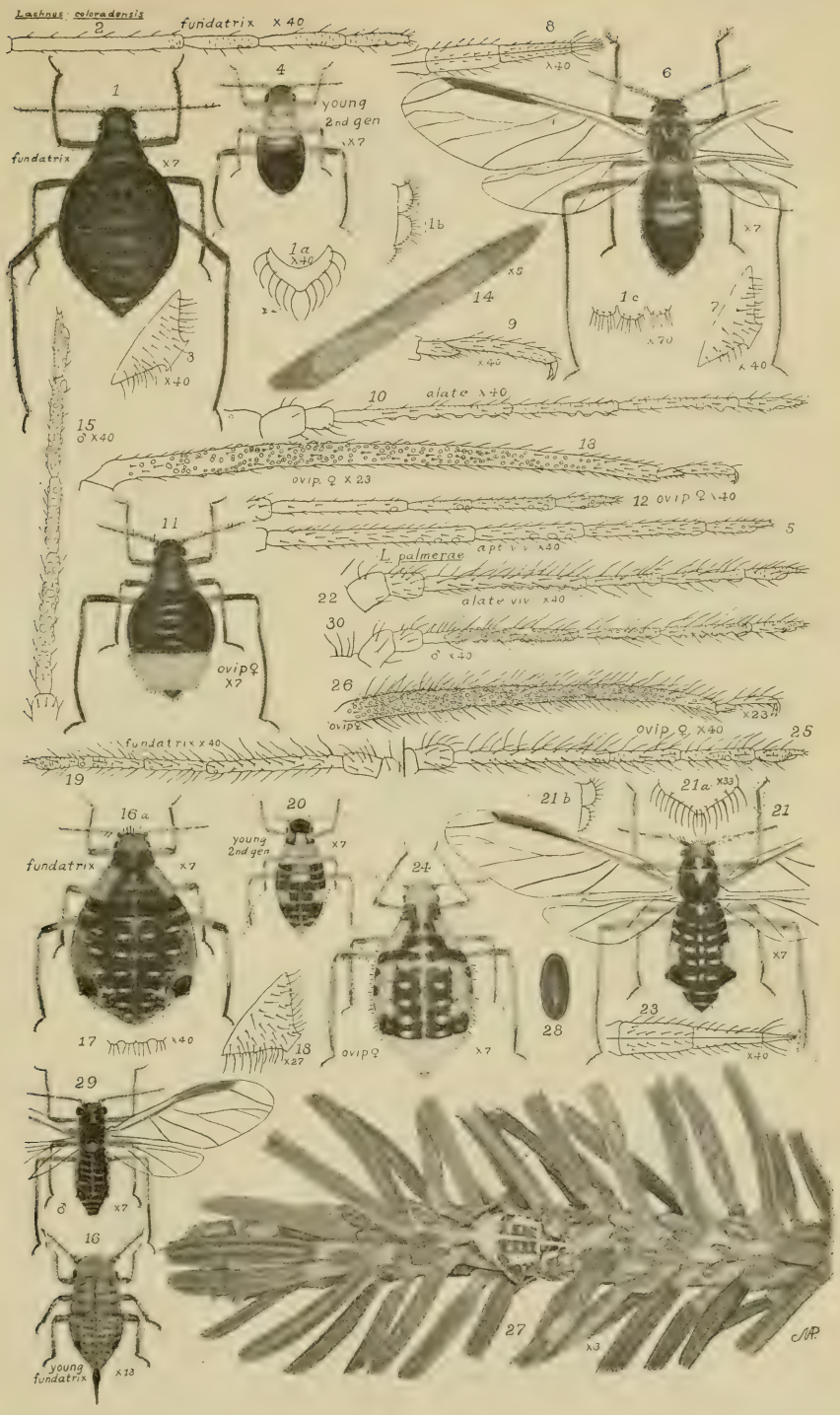
Lachnus palmeræ, n. sp. 16, fundatrix, first instar, × 13; 16a, fundatrix, × 7; 17, gonopophyses of fundatrix, × 40; 18, cornicle of fundatrix, × 27; 19, antenna of fundatrix, × 40; 20, young of second generation, one-half grown, × 7; 21, alate viviparous, second generation, × 7; 21a, cauda of alate viviparous, × 33; 21b, cauda of alate viviparous, side view; 22, antenna of alate viviparous, × 40; 23, terminal three joints of beak of alate viviparous, × 40; 24, oviparous female, × 7; 25, antenna of oviparous, × 40; 26, hind tibia of oviparous, × 23; 27, twig of *Picea engelmanni* with eggs and oviparous female, × 3; 28, egg, × 7; 29, male, × 7; 30, antenna of male, × 40. Original; Miriam A. Palmer, Delineator.

Plate XI.

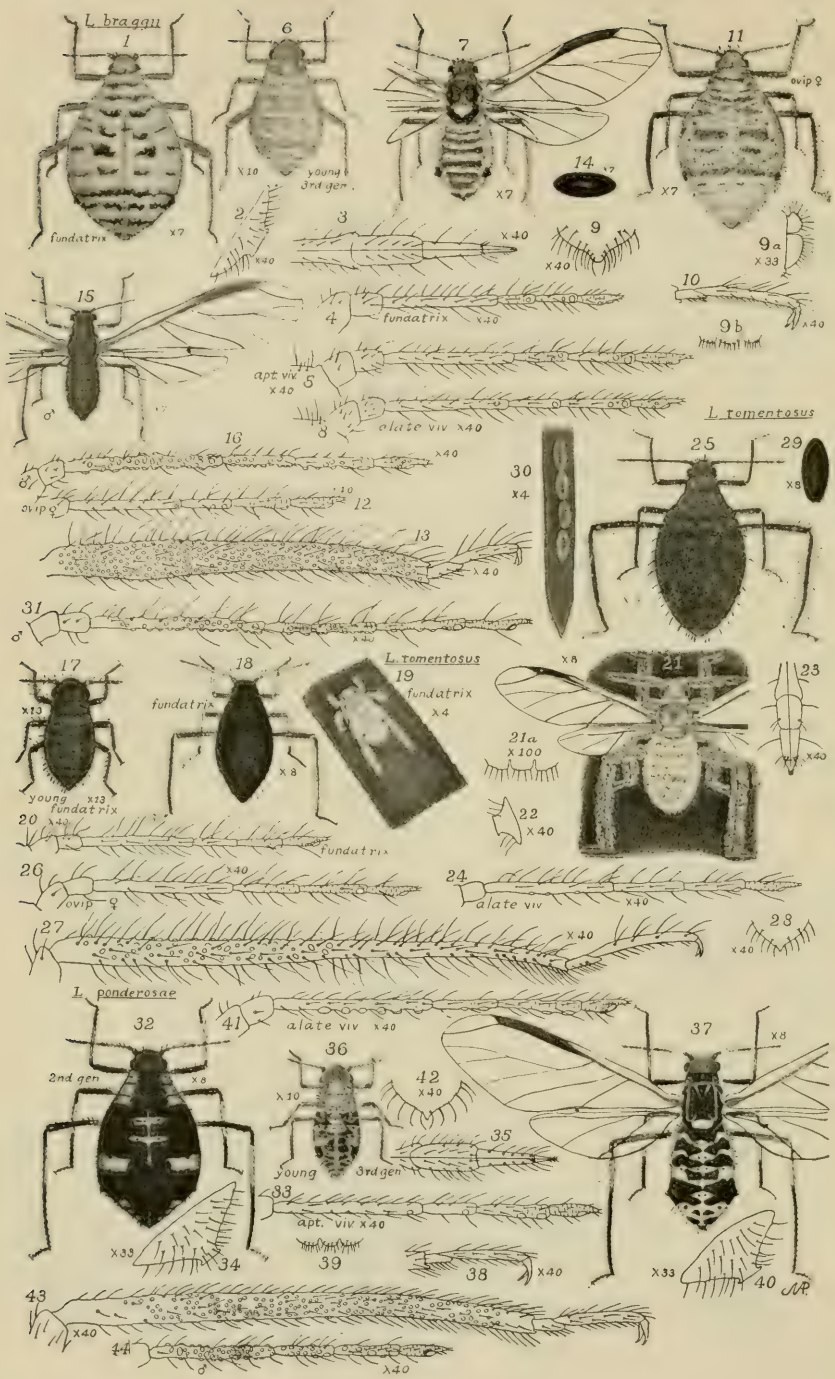
Lachnus braggii, n. sp. 1, fundatrix, × 7; 2, cornicle of fundatrix, × 40; 3, terminal three joints of beak of apterous viviparous, × 40; 4, antenna of fundatrix, × 40; 5, antenna of apterous viviparous, × 40; 6 young of third generation, one-third grown, × 10; 7 alate viviparous, third generation, × 7; 8, antenna of alate viviparous, third generation, × 40; 9, cauda of apterous viviparous, × 40; 9a, cauda of apterous viviparous, side view, × 33; 9b, gonopophyses of apterous viviparous, × 40; 10, tarsal joints of alate viviparous, × 40; 11, oviparous female, × 7; 12, antenna of oviparous female, × 40; 13, tibia of same, × 40; 14, egg of same, × 7; 15, male, × 7; 16, antenna of same, × 40.

Lachnus tomentosus. 17, young fundatrix, × 13; 18, adult fundatrix (with cotton removed), × 8; 19, same with cottony covering on pine needle, × 4; 20, antenna of same, × 40; 21, alate viviparous with cottony covering, × 8; 21a, gonopophyses of same, × 100; 22, cornicle of apterous viviparous, × 40; 23, terminal three joints of beak of oviparous, × 40; 24, alate viviparous antenna, × 40; 25, oviparous female, × 8; 26, antenna of same, × 40; 27, hind tibia of same, × 40; 28, cauda of apterous viviparous, × 40; 29, egg, freshly laid, not yet covered with waxy secretion, × 8; 30, eggs on needle covered with waxy secretion; 31, antenna of male, × 40.

Lachnus ponderosæ Williams. 32, apterous viviparous second generation, × 8; 33, antenna of same, × 40; 34, cornicle of same, × 33; 35, terminal three joints of beak of same, × 40; 36, young of third generation, × 10; 37, alate viviparous, second generation, × 8; 38, tarsus of same, × 40; 39, gonopophyses of same, × 66; 40, cornicle of same, × 33; 41, antenna of same, × 40; 42, cauda of same, × 40; 43, tibia of oviparous, × 40; 44, antenna of male, × 40. Original; Miriam A. Palmer, Delineator.


Lasinus coloradensis
fundatrix x 40
young 2nd gen x7
fundatrix x7
1a x40
1b
1c x70
x5
14
9 x40
3 x40
alate x40
ovip. ♀ x 23
12 ovip ♀ x40
5
L. palmerae apt viv x40
alate viv x40
ovip♀ x7
♂ x40
ovip♀ x23
ovip ♀ x40
25
fundatrix x40
19
16a
fundatrix x7
young 2nd gen x7
17 x40
18 x27
ovip♀ x7
28
21b
21a x33
21
x7
23
x40
29
♂ x7
16
young fundatrix x13
27 x3

C. P. Gillette.


L. bragii
1
fundatrix
x7
6
x10
young
3rd gen.
7
x7
14
x7
11
ovip ♀
x7
2
x40
3
x40
4
fundatrix
x40
9
x40
9a
x33
10
x40
9b
15
♂
apt. viv
x40
5
alate viv x40
8
16
x40
ovip ♀
12
x10
13
x40
31
♂
x40
L. tomentosus
30
x4
25
29
x8
17
x13
young
x13
fundatrix
18
fundatrix
x8
19
fundatrix
x4
L. tomentosus
20
x40
fundatrix
21
x8
21a
x100
22
x40
23
x40
26
x40
ovip ♀
24
alate viv
x40
27
x40
28
x40
L. ponderosae
32
2nd gen
x8
x33
34
41
alate viv x40
36
x10
young
3rd gen
42
x40
35
33
apt. viv x40
39
38
x40
37
x8
x33
40
43
x40
44
♂
x40

C. P. Gillette.

THE PACIFIC COAST SPECIES OF XYLOCOCCUS. (SCALE INSECTS).

LAURA FLORENCE.

In 1882, at the December meeting of the Société Entomologique de France, M. Victor Signoret (12) read a note from Dr. Franz Löw, calling attention to a recent publication by the Société Zoologique et Botanique de Vienne, of the description of a new Coccid for which he had created a new Genus *Xylococcus*.

The paper was published in 1882, under the title of "*Eine neue Cocciden Art* (*Xylococcus filiferus*)" (10). The insect was first discovered and sent to Dr. Löw in 1878, and he had it under observation from that time until the publication of his paper. He described in detail the first larval stage and the adult female, giving only a brief general description of an indefinite number of intervening stages. The remainder of the paper was occupied with notes on the life history, the position of the insects on the tree, and their method of penetrating into the lower layers of the bark.

There is no further reference to *Xylococcus* to be found until 1890, when in a paper entitled "*How do Coccids Produce Cavities in Plants?*" the author, Mr. W. M. Maskell (11), cited it as an example of a cavity-producing Coccid.

In 1898 a paper was published by H. G. Hubbard and Th. Pergande (6) on a new Coccid found on birch trees. Thus a second species of *Xylococcus* was recorded, the first to be found in America. This, having been found on birch trees in Lake Superior region, was named *Xylococcus betulæ* by Mr. Pergande. The paper was in two parts, the first by Mr. Hubbard was biological, the second by Mr. Pergande structural. In this paper were well pointed out the extremely interesting peculiarities, both structural and physiological, of these curious Coccids.

Both the above-mentioned species were listed by Professor T. D. A. Cockerell (1) in his "*Tables for the Determination of the Genera of Coccidæ.*" He divided the sub-family *Margarodinæ* into two tribes, *Margarodini* and *Xylococcini*. In the latter he placed *Xylococcus* and two allied Genera *Coleostoma* and *Callipappus*.

In the following year, 1900, Mr. E. M. Ehrhorn (5) published a short description of a third *Xylococcus*, which he found on a species of live oak in Stevens Creek Canyon, Santa Clara County, California, and named *Xylococcus quercus*.

In 1902 Professor Cockerell (2) included a brief description of the Genus in "*A Contribution to the Classification of the Coccidæ.*" Reference was made to the work of Löw and of Hubbard and Pergande, and the three known species listed.

In 1905, Mr. S. I. Kuwana (7) presented a description of a fourth species, *Xylococcus matsumuræ*. Three years later a second Californian species was found on the Monterey Cypress trees near Pacific Grove, Monterey County, by Mr. G. A. Coleman (4). He made some short notes on the species, naming it *Xylococcus macrocarpæ*. In the following year, 1909, Professor Cockerell (3) referred *Xylococcus matsumuræ* to a new Genus *Matsucoccus* on the basis of the anal tube and the character of the last joint of the antenna.

Dr. Leonhard Lindinger (9) in his textbook on Scale Insects, published in 1912, gives a brief description of *Xylococcus filiferus* Löw. This has been taken from the original paper.

In 1914, Mr. S. I. Kuwana (8) described a scale insect from oak trees (*Quercus serata*) at Nishigahara, Tokyo, and other places in Japan. He named it *Xylococcus napiformis* n. sp., acknowledging Professor Cockerell's assistance in the determination of the species.

Of the two Californian species, *Xylococcus macrocarpæ* Cole, and *Xylococcus quercus* Ehrh., each stage in the life history of the female and five stages in that of the male are described in detail in this paper. A new species from alder trees is described and I have called it *Xylococcus alni n. sp.* It was collected at Wenatchee, in the State of Washington, by Mr. E. J. Newcomer, of the Bureau of Entomology, who sent it to the Entomological Laboratory of Stanford University.

The distribution of this small group of Coccids presents some interesting features. They have been found on three continents, Europe, America, and Asia, and up to the present time each species has been recorded from one host plant only, *Xylococcus filiferus* Löw, infesting linden trees in Lower Austria, *Xylococcus betulæ Perg.*, infesting birch trees on the shores of Lake Superior, *Xylococcus quercus Ehrh.*, and *Xylococcus napiformis Kuw.*, infesting different species of oak trees, the

former in California and the latter in Japan, *Xylococcus macrocarpæ Cole.* infesting the Monterey Cypress, and *Xylococcus alni n. sp.*, infesting alder trees. From this list it is seen that not only are those insects widely distributed geographically, but they are found on widely separated species of host plant. Nothing is known as to how the trees have become infested, or how the insects penetrate into the lower layers of the bark, where they are found surrounded by secretions of wax.

It is of peculiar interest that the Monterey Cypress, the host of *Xylococcus macrocarpæ Cole.* (Pl. XII, Fig. 1), is indigenous to a single area in California known as Del Monte Forest and extending for a few miles along the Pacific Coast in Monterey County. While collecting my specimens I found the insects on old and young trees alike. The infestation is not evenly distributed in the forest and the most heavily infested trees are easily distinguishable even at a distance by their black colour, due to the growth of a sooty mould fungus in the honey dew exuded by the insects.

Xylococcus quercus Ehrh. (Pl. XII, Fig. 2) I have collected from oak trees (Quercus chrysolepis Liebmann) in Permenente Creek Canyon, Santa Clara County. There is a slight growth of sooty mould fungus on these infested trees also.

These insects infest the trunk and older branches of the trees, and their presence is indicated by numerous filaments of wax protruding from crevices in the bark and bearing drops of honey dew. There is great variety in the length and appearance of these filaments, some being straight, others wavy and almost spiral. This filament is a capillary tube issuing from the posterior end of the body from a chitinous organ called the anal tube, and formed by an extension of the outer walls of circles of chitinous spinnerets, that open into and surround the posterior end of the alimentary canal. Gross dissection shows the insects imbedded between the layers of the bark with their mouth-parts penetrating more deeply. They are surrounded by a homogeneous layer of wax that is given off from pores scattered over the body (Pl. XIII, Fig. 1). The apodous stages of the insect are found in greatest number and in the case of *Xylococcus macrocarpæ Cole.* the characteristic position is in groups varying in number (Pl. XII, Fig. 3). *Xylococcus quercus Ehrh.* (Pl. XIII, Fig. 2) and *Xylococcus alni n. sp.* (Pl. XIII, Fig. 3), are seldom found in groups and their pits are more or less

circular. In the case of the latter the presence of a pit seems to be indicated by a small swelling on the bark. Alongside the insects are found fragments of the wax covering and of the exuviae of previous instars.

The life histories seem to be identical with that of *Xylococcus betulæ Perg.* as previously described. I have not succeeded, however, in finding a stage in the development of the male insect of *macrocarpæ*, or *quercus*, or *alni*, corresponding to Pergande's second stage of *betulæ*. The mouth-parts are very long, and when the larvæ first hatch can be seen coiled inside the insect (Pl. XIII, Fig. 4). The young insects have well developed legs and move about actively before settling down. The male and the female are apparently not distinguishable in the first stage. After the first moult the female loses its legs and antennae and for three successive stages is apodous. Size, difference in number of the wax pores, and structural differences in the stigmatal tubes and anal tube serve to distinguish these stages. After the fourth moult the adult female issues. The insect has now regained the legs and antennæ, but lost the mouth parts (Pl. XIII, Fig. 5). The insect may, without escaping from the exuvia of the fourth stage, rupture the end of the exuvia and present the posterior end of the body at the crevice in the bark for impregnation by the male, or she may escape from the pit and move about freely over the tree. In this case she finally settles under some projection of the bark and spins a cushion of flocculent wax beneath and a covering of powdery wax above her (Pl. XII, Fig. 4). When the eggs are laid the abdomen becomes concave on the lower surface with the lateral margins revolute, so forming a pocket in which the eggs lie buried in wax until they hatch (Pl. XIII, Fig. 6). After egg-laying the female dies, the anterior part of the body shrivelling up.

At the second moult the male insect becomes apodous, closely resembling the female of the third stage. In the fourth stage the legs and antennæ reappear and the mouth-parts and the chitinized anal tube are lost. The insect now emerges and wanders freely over the bark, finally settling under some raised part of the bark. It immediately begins to spin a long slender cylindrical cocoon of flocculent wax and within this the transformation to the pupal stage takes place. The pupæ have well

developed free legs and antennæ (Pl. XIII, Fig. 7), and the adult male (Pl. XIII, Fig. 8) issues from the anterior end, escaping from the cocoon through a small circular aperture. The male is a beautiful insect with two abdominal brushes composed of brittle wax rods produced from groups of pores on the dorsal surface of the sixth and seventh abdominal segments. These brushes are longer than the insect.

The observations on the life history have been made from the trees where the material was collected and from branches brought into the laboratory and kept alive in water. The different stages were collected throughout the year. The males appear to issue during autumn and early winter and females with eggs are found during winter and spring. The larvæ from the eggs of one adult hatch over a considerable period of time. In the laboratory I have had them hatching successively from the same mass of eggs for over six weeks and in the field I found similar conditions.

The biology of these insects was admirably written up by Mr. H. G. Hubbard (6) in 1898, but a few more facts can now be added. In the adopous stages no external traces of the legs remain, but the antennæ are represented by microscopic chitinous discs bearing a few long and a few short hairs. The pigmented eye spots that disappear on boiling the specimens in KOH, are situated near, but not contiguous to these antennal discs. The insects have ten pairs of spiracles, two pairs on the thorax and eight pairs on the abdomen. Those on the abdomen have large simple openings, and within the body form stigmatal tubes with an anterior constriction in which there are one or two rings of pores according to the instar. The thoracic spiracles have no stigmatal tubes. In the active stages their openings are marked by a small group of pores, and in the apodous stages these pores are wanting. In the successive apodous instars an increasing development of the anal tube is visible and this is one of the means of distinguishing them. Mr. Hubbard laid stress on the unusual life history of *Xylococcus betulæ Perg.* and pointed out many peculiarities of structure, showing parallels to them in several species of *Coelostoma Mask.* (*Coelostomidia Ckll.*) and of *Margarodes Guilding.* He suggested that these belonged to a hitherto unrecognized subfamily of the Coccidæ. Since that time *Xylococcus* and five other genera, *Margarodes*, *Coelostoma*, *Callipappus*, *Kuwania*

and *Matsucoccus* have been placed in a new sub-family *Margarodinæ*. The common characters of the sub-family are, in the female, the absence of legs and antennæ in the intermediate stages and of mouth-parts in the adult, in the adult male, the presence of compound eyes. The following table will assist in the identification of the North American species of *Xylococcus*.

I. In first larval stage one median ventral pore.
In apodous stages anal tube without median circles of spinnerets.
macrocarpæ Cole.

II. In first larval stage more than one median ventral pore.
In apodous stages anal tube with median circles of spinnerets.
a. Anal tube with one median circle of spinnerets. Five median ventral pores *betulæ Perg.*
b. Anal tube with two median circles of spinnerets. Median pores varying from 2 to 4 *quercus Ehrh.*
c. Anal tube with three median circles of spinnerets. Median pores varying from 6 to 7 *alni* n. sp.

Xylococcus macrocarpæ Cole.

Eggs.—Length, .55 mm., diameter, .275 mm.; oval, highly polished; colour pale lemon yellow.

Larva, first stage.—Length about .7 mm., diameter about .3 mm. Color on hatching very pale yellow, later becoming tinged with red. Shape oblong-oval, sides sub-parallel narrowing a little posteriorly. Segments all well defined. Eyes black, situated on prominences lateral and posterior to antennæ (Pl. XIV, fig. 1e). Antennæ six-jointed, short, stout; formula 6, 1, 2, 5, (3, 4); joint one stoutest, joints two to five approximately equal in diameter, last joint slender; all joints except three and four bearing hairs that increase in length towards apex; on joint five at base of exterior lateral edge a stout spine; on joint six a ring of four stout spines and a single spine on apex; a very long bristle at apex; a single pore on joint two (Pl. XIV, fig. 1). Legs long and stout; tarsus longer than tibia; a ring of pores, one long hair and one short one on trochanter; digitules on tarsus fine unknobbed hairs, on claw knobbed hairs (Pl. XIV, fig. 2). Rostrum large, situated about middle of body; sucking bristles very long. Anal tube rather short and broad, formed by an extension of the outer walls of a circle of chitinous spinnerets which surround and open into the posterior end of the alimentary canal. Spiracles, two pairs on thorax, eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes (Pl. XIV, fig. 3). Body with hairs sparsely scattered over cephalic and thoracic areas, and on dorsal and ventral surfaces of abdomen in transverse rows, one on each segment; a pair of backward directed short lateral spines on each abdominal segment; on ventral surface of segment eight single long lateral bristles; pores of three types; a simple median ventral pore anterior to anal tube; compound lateral pores on each thoracic and first seven abdominal segments dorsally and ventrally; small pores as follows—a pair on cephalic area anterior to prothorax, a pair on the mesothorax, a pair on the metathorax, a pair

on the eighth abdominal segment ventrally; dorsally two pairs on the last two abdominal segments; a single pore adjacent to each abdominal spiracle; in lateral view pores are short chitinous tubes (Pl. XIV, figs. 4a and 4b).

Female, second, third and fourth stages.—Length from about 1.50 mm. to about 4 mm., breadth from about .75 mm. to about 2 mm. Color dark red, posterior end of body brown owing to chitinous nature of last abdominal segments. Shape oblong-oval, bluntly rounded anteriorly; abdominal segments well marked, posterior segments being more compressed than in stage one. Eyes represented by small black pigment spots (disappearing on boiling in KOH), situated near but not contiguous to antennal discs. Antennæ represented by microscopic chitinous discs bearing a few hairs varying in length and number. Legs wanting. Rostrum large, situated about middle of body. Anal tube in second stage with an increased number of spinnerets opening into it anteriorly, in third stage with two anterior circles of spinnerets, and in fourth stage with three anterior circles of spinnerets (Pl. XIV, fig. 5). Two pairs of thoracic and eight pairs of abdominal spiracles; the former inconspicuous, the latter with well developed stigmatal tubes differing from those of first stage as illustrated (Pl. XIV, figs. 3 and 6), and increasing in length in the successive instars; one row of pores in constriction in second and third and two rows in fourth stage. Integument smooth and shining, bearing a few microscopic hairs, and a few lateral abdominal spines. Pores of two types, (Pl. XIV, fig. 7), compound type predominating, distributed irregularly on cephalic and lateral areas and arranged in transverse rows on segments two to seven of abdomen, simple type of pore interspersed among compound type. In successive stages hairs and spines increase in size and pores in number. Pores much more numerous in fourth than in preceding stages, arranged in bands on abdomen, and in all stages increasing in number posteriorly.

Female, fifth stage, adult.—The adult varies in length from 6 mm. to 3 mm. and in breadth from 3 mm. to 1.50 mm.; measurements of largest and smallest specimens found when moulting were respectively 5 mm. x 2.50 mm. and 3 mm. x 1.50 mm., specimens found with eggs 6 mm. x 3 mm. and 4 mm. x 2 mm. Color when living dark olive brown, with an indistinctly spotted appearance due to dark particles in the body fluid; on ventral surface revolute edges yellow; antennæ and legs yellow. Shape oblong-oval, broadest in thoracic region; segments all well defined. Eyes small, black, situated laterad to antennæ. Antennæ stout, nine-jointed; formula 1, 3, 2, (4, 8, 9), 5, (6, 7); joint one longest and stoutest; joint three longer and more slender than two (division between joints two and three not always clearly defined); joints four, five, eight, and nine sub-equal in length and diameter; segments four to eight widening anteriorly where they bear a fringe of hairs; hairs increasing in length towards apex of antenna; last joint flattened at apex, longer at outer side, bearing a few spines as well as hairs; on joint two a small group of pores varying in number, sometimes absent (Pl. XIV, fig. 8). Legs stout and rather short; tibia twice as long as tarsus; trochanter bearing two long hairs and a group of pores varying

in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XIV fig. 9). Rostrum wanting. Anal tube represented by an infolding of the body wall, not strongly chitinized. Two pairs of spiracles on thorax, eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with two irregular rows of pores in constriction. Integument covered with short stiff hairs stoutest and most numerous anteriorly; a few short spines at posterior end; pores of two types scattered over body (Pl. XIV, fig. 10); on abdomen arranged in indefinite bands; around vaginal opening, which is situated on ventral surface of seventh abdominal segment, they form a dense ring; smaller type of pore predominates.

Male, second stage.—Not found.

Male, third stage.—Length about 2.5 mm., breadth about 1 mm. Similar to stage three of female, but pores on body less numerous. Three posterior abdominal segments chitinised.

Male, fourth stage.—Length about 2.5 mm., breadth about .75 mm. Color dark brownish red; legs light yellow, antennæ dark yellow. Shape oblong with sides sub-parallel; posterior end bluntly rounded; segments all well defined. Eyes large, black; situated laterad to antennæ. Antennæ rather short and stout; formula 1, (2, 3, 9), 8, (4, 5, 7), 6; joint one stoutest, the others gradually diminishing in diameter; joints six to eight broadest anteriorly; nine longer at one side than the other; each joint bearing hairs increasing in length towards apex, terminal joint bearing a few spines as well as hairs; second joint bearing a group of pores varying in number (Pl. XIV, fig. 11). Legs well developed, bearing many stout hairs especially on tibia; tibia almost two and a half times as long as tarsus; trochanter bearing two long hairs and a group of pores varying in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XIV, fig. 12). Rostrum wanting. Anal tube wanting. Two pairs of spiracles on thorax, eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with one row of pores in constriction. Integument covered with microscopic short, sharp hairs, stouter and more numerous on posterior segments; long, stout hairs and pores of one type (Pl. XIV, fig. 13) thickly scattered over cephalic area; on thorax and abdomen pores arranged in bands segmentally; hairs increasing in number and size posteriorly.

Male, fifth stage.—Cast skin. Length about 1.75 mm., breadth about .7 mm. Color pinkish red; antennæ dusky; legs dark yellow. shape oblong, sides sub-parallel, tapering slightly towards the posterior end; segments all well defined; wing pads reaching end of third abdominal segment. Antennæ long, nine-jointed; formula 9, 2, 3, (1, 8), 6, 5, (4, 7); all joints sub-equal in diameter; without hairs (occasionally a few short hairs present on first joint) (Pl. XIV, fig. 14). Legs long and stout; tarsus about one-third length of tibia with vestigial claw; short hairs present on all joints except tarsus; a group of pores varying in number on trochanter (Pl. XIV, fig. 15). Integument with hairs scattered over cephalic and thoracic areas; on abdomen arranged in

transverse rows corresponding to segments; a few pores of same type as in stage four (Pl. XIV, fig. 13) interspersed among abdominal hairs; a polygonal protuberance at end of body.

Male, sixth stage, adult.—"Length; body 2 mm., width across thorax .8 mm., wings 3 mm. long by 1 mm. broad, expanse about 7 mm.; color of head and thorax dark brown, abdomen yellow, with bands of brown above and below, wings cinereous; veins blackish; only one distinct branch to discoidal vein." (Coleman).

Eyes large, prominent and coarsely facetted. Antennæ ten-jointed, reaching middle of abdomen; joints one and two short and stout; joint three longest; remaining joints diminishing in length and diameter towards apex; all bearing numerous irregularly distributed fine hairs. Two pairs of wings; front pair cinereous with irregularly reticulate surface; discoidal vein with one distinct branch (tending to disappear in mounted specimens); hind wings very small, bearing three stout hooks at apex (Pl. XIV, fig. 16). Legs long, bearing numerous hairs particularly on tibia; tibia nearly twice as long as femur and nearly four times as long as tarsus; tarsus two-jointed, first joint short; digitules fine unknobbed hairs (Pl. XIV, fig. 17). Short fine hairs scattered over integument; on dorsal surface of sixth abdominal segment two groups, each of fifteen pores, on the seventh segment two groups, each of twelve pores (it is from these pores that the abdominal brush issues); style short and conical, with a broad base; sexual organ as long as abdomen and finely annulated (annulations showing under high power of microscope) (Pl. XIV, fig. 18).

Xylococcus quercus Ehrh.

Eggs.—Length .65 mm., diameter .34 mm.; oval, highly polished; color varying from pale orange yellow to light red.

Larva, first stage.—Length varying from .65 mm. to .75 mm., diameter from .35 mm. to .40 mm. Color orange red. Shape broadly oval; segments all well defined. Eyes black, situated on prominences posterior and laterad to antennæ (Pl. XIV, fig. 19e). Antennæ short, stout; six-jointed; formula 6, 1, 5, 2, 4, 3; joint one stoutest; remaining joints approximately equal in diameter; joints three and four without hairs; hairs on joints one, two, five and six increasing in length towards apex; on joint five at base of exterior lateral edge a stout spine; on joint six a ring of four stout spines near the base and a single spine on the apex, a very long bristle at apex; a single pore on joint two (Pl. XIV, fig. 19). Legs long and stout; tarsus longer than tibia; a ring of pores and one long hair on trochanter; a few hairs on tibia and tarsus; digitules on tarsus fine unknobbed hairs, on claw knobbed hairs (Pl. XV, fig. 1). Rostrum large, situated about middle of body; sucking bristles very long. Anal tube protruding from body, being an extension of the outer walls of two groups of chitinous spinnerets that open into the posterior end of the alimentary canal. Two pairs of spiracles on thorax, eight pairs on abdomen; the former inconspicuous; the latter with well developed stigmatal tubes (Pl. XIV, fig. 3). Integument smooth and

shining, after clearing in KOH seen to be covered with microscopic pits, increasing in size posteriorly; hairs scattered over cephalic and thoracic areas, and on dorsal and ventral surfaces of abdomen in transverse rows, one on each segment; a pair of backward directed lateral spines increasing in size posteriorly on each abdominal segment; on ventral surface of segment eight single long lateral bristles; pores of three types—a median ventral row of large pores anterior to anal tube and varying in number from two to four; medium-sized lateral pores on each abdominal segment dorsally and ventrally; small pores as follows: a pair on the mesothorax, a pair on the metathorax, two pairs on each segment of the abdomen ventrally; dorsally a pair on the metathorax, two pairs on the first seven abdominal segments and three pairs on the eighth; in lateral view pores resemble short chitinous tubes (Pl. XIV, figs. 20a and 20b).

Female, second, third and fourth stages.—Length from about 1 mm. to 4 mm., breadth from about 1.75 mm. to about 3 mm. Color deep red, posterior end of body brown owing to chitinous nature of last abdominal segments. Shape sub-spherical; segments not clearly defined; posterior segments more compressed than in stage one. Eyes represented by small black pigment spots (disappearing on boiling in KOH), situated near, but not contiguous to antennal discs. Antennæ represented by microscopic chitinous discs bearing a few hairs varying in length and number. Legs wanting. Rostrum large, situated about middle of body. Anal tube in second stage with an increased number of spinnerets opening into it anteriorly and a sparse median transverse circle of spinnerets, in third stage with three anterior circles of spinnerets and one median transverse circle, in fourth stage with five anterior circles of spinnerets and two median transverse circles (Pl. XIV, fig. 21). Two pairs of thoracic and eight pairs of abdominal spiracles; the former inconspicuous, the latter with well developed stigmatal tubes differing from those of first stage as illustrated (Pl. XIV, figs. 3 and 6), and increasing in length in the successive instars; one row of pores in constriction in second and third stages and two rows in fourth stage. Integument smooth and shining; after clearing in KOH seen to be covered with microscopic pits, increasing in size posteriorly; lateral abdominal spines increasing in size posteriorly; a few hairs scattered over body. Pores of two types (Pl. XV, fig. 2)—large pores scattered on anterior cephalic area; a few small lateral pores on thorax, large and small pores arranged in transverse rows on segments one to seven of abdomen. In the successive stages hairs and spines increase in size and pores in number. Pores much more numerous in fourth than in preceding stages, and in all stages increasing in number posteriorly.

Female, fifth stage, adult.—Length varying from 5.5 mm. to 4 mm., breadth from 4 mm. to 3 mm. Color when living dull brownish red; antennæ and legs brighter. Shape oval, broadest in thoracic region, broadly rounded at posterior end; segments all well defined. Eyes small, black; situated laterad to antennæ. Antennæ long, stout, nine-jointed; formula 1, 9, 2, 3, 6, 4, 7, (5, 8); joints one to four stoutest;

joints five to eight sub-equal; joint nine slender; on joints one and two hairs scattered, on joints three to eight arranged in a fringe at anterior edge and increasing in length towards apex of antenna; terminal joint bearing a ring of four stout spines, two long hairs and a number of shorter hairs; on joint two a group of pores varying in number (Pl. XV, fig. 3). Legs very stout; tibia twice as long as tarsus; trochanter bearing two long, a number of shorter hairs and a group of pores varying in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XV, fig. 4). Rostrum wanting. Anal tube represented by an infolding of body wall, not strongly chitinised. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes bearing two rows of pores in constriction. Integument covered with short hairs, most numerous on dorsal and lateral areas, and on ventral surface of abdomen arranged in transverse rows segmentally; pores of two types (Pl. XV, fig. 5) thickly scattered over cephalic and thoracic areas, and on abdomen arranged in transverse bands segmentally, the bands on dorsal surface being broader and more dense than those on ventral surface; around vaginal opening pores become more numerous; smaller type of pore predominates.

Male, second stage.—Not found.

Male, third stage.—Similar to stage three of female, but longer and more slender. Pores on body less numerous than on stage three of female; six posterior abdominal segments strongly chitinised.

Male, fourth stage.—Length 2 mm., breadth 1.3 mm. Color deep red; legs and antennæ yellow. Shape oblong, broadest in thoracic region; head and thorax together longer than abdomen; segments all well defined. Eyes small, black, situated laterad to antennæ. Antennæ rather short and stout; nine-jointed; formula 1, 2, 9, 3, 7, (4, 8), 6, 5; joints one to three stoutest; joints four to eight sub-equal; joint nine slender; hairs on each joint increasing in length towards apex, on joints three to eight forming a fringe at anterior extremity; a few spines as well as hairs borne on terminal segment; on joint two a group of pores varying in number (Pl. XV, fig. 6). Legs well developed, bearing many stout hairs; tibia twice as long as tarsus; trochanter with one long hair and a group of pores varying in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XV, fig. 7). Rostrum wanting. Anal tube wanting. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with one row of pores in constriction. Integument covered with microscopic short, sharp hairs, stouter and more numerous on posterior segments; long stout hairs and pores of one type (Pl. XV, fig. 8) thickly scattered over cephalic area; on thorax and abdomen these are less numerous and are arranged in bands segmentally; hairs increasing in number and size posteriorly.

Male, fifth stage, pupa.—Cast skin. Length about 2 mm., breadth about 1 mm. Color of abdomen deep red; thorax, legs and antennæ yellow; in dried specimens pigment is broken up, causing a spotted appearance (Pl. XIII, fig. 7). Shape rather broad and short; head and

thorax together longer than abdomen; wing pads broad, reaching beyond hind coxæ. Antennæ long, nine-jointed; formula 1, 3, (4, 5), 9, 6, 2, 7, 8; all joints sub-equal in diameter and distally annulated with white; without hairs (occasionally a few short ones on joint one) (Pl. XV, fig. 9). Legs long and stout, tarsus little more than one-third length of tibia with vestigial claw; short hairs present on all joints except tarsus; trochanter bearing a group of pores varying in number (Pl. XV, fig. 10). Integument with hairs scattered over cephalic and thoracic areas; on abdomen arranged segmentally in transverse rows; a few pores of same type as in stage four (Pl. XV, fig. 8) interspersed among abdominal hairs; a polygonal protuberance at end of body.

Male, sixth stage, adult.—"About 3 mm. long and 1.5 mm. broad, slightly pubescent. Color of abdomen reddish brown. Mesothorax black, with four raised knobs. Front part of head black, eyes very prominent, strongly facetted, black. Legs and antennæ black and very hairy. Ventral surface of abdomen dark brown, segmentation distinct. Mesosternum black, a small black line on prosternum, and an irregular black patch on metasternum. Abdominal brushes with long stout glassy bristles about 6 mm. long. Style short, stout and conical. Antennæ ten-jointed, very hairy, reaching beyond end of abdomen. Joint two shortest, joints three and ten a little longer, and the other joints sub-equal. Each joint with numerous hairs. Wings large, about 3 mm. long and 1 mm. broad, expanse about 7 mm., smoky, slightly pubescent, with the costal space blackish-brown. Halteres resembling small wings with several hooks. Legs long and very hairy. Femur much shorter than tibia. Tibia about four times as long as tarsus. Digitules fine hairs. Claw long and slender and well curved. Digitules short club-shaped hairs." (Ehrhorn).

Xylococcus alni n. sp.

No measurements of this insect were taken, because only dried specimens were at hand.

Eggs.—Color deep lemon yellow.

Larva, first stage.—Color orange red. Shape broadly oval, segments all well defined. Eyes black; situated on prominences lateral and posterior to antennæ (Pl. XV, fig. 11e). Antennæ short, stout, six-jointed; formula 6, 2, 1, (4, 5), 3; joints one and two stoutest; remaining joints approximately equal in diameter; joints three and four without hairs; hairs on joints one, two, five, and six increasing in length towards apex of antenna; on joint five at base of exterior lateral edge a stout spine; on joint six a ring of four stout spines near the base and a single spine on apex; a very long bristle at apex; a single pore on joint two (Pl. XV, fig. 11). Legs long and stout; tarsus longer than tibia; a ring of pores and one long hair on trochanter; a few hairs on tibia and tarsus; digitules on tarsus fine unknobbed hairs, on claw knobbed hairs (Pl. XV, fig. 12). Rostrum large; situated about middle of body; sucking bristles very long. Anal tube large; formed by an extension of the outer walls of a circle of chitinous spinnerets which surround and open

into the posterior end of the alimentary canal. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes (Pl. XIV, fig. 3). Integument smooth, after clearing in KOH seen to be covered with microscopic pits increasing in size posteriorly; hairs sparsely scattered over cephalic and thoracic areas, arranged in transverse rows segmentally on dorsal and ventral surfaces of abdomen; a pair of backward directed lateral spines increasing in size posteriorly on each abdominal segment; on ventral surface of segment eight single lateral long bristles; pores of four types—type I, a median ventral row of large pores anterior to anal tube and varying in number from six to seven; type II, medium-sized lateral pores on each abdominal segment dorsally and ventrally; type III, small pores as follows, a pair on the mesothorax and a pair on the metathorax ventrally, dorsally a pair on the metathorax, a pair on first abdominal segment, and two pairs on the succeeding segments; type IV, very small pores on dorsal surface of segments two to eight of abdomen (Pl. XV, figs. 13a and 13b).

Female, second, third and fourth stages.—Color red, posterior end of body brown, owing to chitinous nature of last abdominal segments. Shape ovoid, broadest in thoracic region, bluntly rounded anteriorly; abdominal segments well marked, posterior segments more compressed than in stage one. Eyes represented by small black pigment spots (disappearing on boiling in KOH), situated near, but not contiguous to antennal discs. Antennæ represented by microscopic chitinous discs bearing a few hairs varying in length and number. Legs wanting. Rostrum large, situated about middle of body. Anal tube in second stage with additional anterior spinnerets and a few median spinnerets, in third stage with an increased number of spinnerets, in fourth stage with two anterior circles of spinnerets and three median transverse circles of spinnerets (Pl. XV, fig. 14). Two pairs of thoracic and eight pairs of abdominal spiracles, the former inconspicuous, the latter with well developed stigmatal tubes, differing from those of first stage as illustrated (Pl. XIV, figs. 3 and 6), and increasing in length in the successive instars, one row of pores in constriction in second and third stages and two irregular rows in fourth stage. Integument smooth, after clearing in KOH seen to be covered with microscopic pits increasing in size posteriorly; a few microscopic hairs on lateral areas; a few small lateral spines posteriorly. Pores of two types (Pl. XV, fig. 15); large pores scattered sparsely on cephalic and thoracic areas; on abdomen large and small pores arranged in transverse rows segmentally; small lateral pores scattered on abdomen. In the successive stages hairs and spines increase in size and pores in number. Pores much more numerous in fourth than in preceding stages and arranged in bands segmentally on abdomen. In all stages pores increase in number posteriorly.

Female, fifth stage, adult.—Color dark red. Shape oblong-oval; segments all well defined. Eyes small, black, laterad to antennæ. Antennæ long and stout; nine-jointed; formula 1, 9, 2, (3, 7), 5, (4, 6, 8); joints one to three stoutest; joints four to eight sub-equal; joint nine

slender; hairs on joints one and two irregular, on joints three to eight distributed in a fringe on widest anterior part of segment; on terminal joint hairs and spines; hairs increasing in length towards apex of antenna; on joint two a group of six pores (Pl. XV, fig. 16). Legs stout and short; tibia more than twice as long as tarsus; trochanter with two long hairs and a group of pores varying in number; hairs on all parts, most numerous on tibia; digitules on tarsus and on claw fine unknobbed hairs (Pl. XV, fig. 17). Rostrum wanting. Anal tube represented by an infolding of the body wall and not strongly chitinised. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with two rows of pores in constriction. Integument covered with hairs, becoming more numerous posteriorly; pores of two types (Pl. XV, fig. 18) densely scattered over cephalic region and less densely over thorax and abdomen; smaller type of pore predominating.

Male, second stage.—Not found.

Male, third stage.—Similar to stage three of female; pores less numerous than in stage three of female; six posterior abdominal segments strongly chitinised.

The fourth, fifth and six stages of the male of this species have not yet been found.

This study has been made in the Entomological Laboratory of Stanford University, and there, are preserved the type specimens of *Xylococcus alni n. sp.*

The drawings on Plate XIII and figures three and six on Plate XIV are the work of Mr. W. S. Atkinson. The other drawings were made with a camera lucida, and an oil immersion was used in studying the structure of the wax pores.

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EXPLANATION OF PLATES.

PLATE XII.

No. 1. *Xylococcus macrocarpæ* Cole. on Monterey Cypress, showing filaments.
No. 2. *Xylococcus quercus* Ehrh. on Quercus chrysolepis, showing filaments.
No. 3. Position of *Xylococcus macrocarpæ* Cole. under bark.
No. 4. *Xylococcus quercus* Ehrh., adult females.

PLATE XIII.

Fig. 1. *Xylococcus quercus* Ehrh., fourth stage of female.
Fig. 2. Position of *Xylococcus quercus* Ehrh., bark removed.
Fig. 3. Pits of *Xylococcus alni* n. sp., insects removed. a, dorsal; b, ventral.
Fig. 4. *Xylococcus quercus* Ehrh., first larval stage.
Fig. 5. *Xylococcus macrocarpæ* Cole., adult female, a dorsal; b, ventral.
Fig. 6. *Xylococcus quercus* Ehrh., adult female showing egg-mass.
Fig. 7. *Xylococcus quercus* Ehrh., pupa of male insect.
Fig. 8. *Xylococcus macrocarpæ* Cole., adult male.

PLATE XIV.

Xylococcus macrocarpæ Cole.

Fig. 1. Antenna of first larval stage; e, eye.
Fig. 2. Leg of first larval stage.
Fig. 3. Abdominal stigmatal tube of first larval stage.
Fig. 4. Posterior segments of abdomen of first larval stage, showing spines, pores, anal tube, and stigmatal tubes; a, dorsal; b, ventral.
Fig. 5. Anal tube of fourth stage of female; a, alimentary canal; b, anterior spinnerets; dd, posterior stigmatal tubes.
Fig. 6. Abdominal stigmatal tube of fourth stage of female, showing two rows of pores in constriction.
Fig. 7. Body pores of apodous stages of female.
Fig. 8. Antenna of adult female.
Fig. 9. Leg of adult female.
Fig. 10. Body pores of adult female.
Fig. 11. Antenna of fourth stage male.
Fig. 12. Leg of fourth stage male.
Fig. 13. Body pore of fourth and fifth stages of male.
Fig. 14. Antenna of pupa of male.
Fig. 15. Leg of pupa of male.
Fig. 16. Hind wing of adult male.
Fig. 17. Leg of adult male.
Fig. 18. Posterior end of body of adult male; a1, groups of pores; a2, pore enlarged; b, sexual organ.

Xylococcus quercus Ehrh.

Fig. 19. Antenna of first larval stage; e, eye.
Fig. 20. Posterior segments of abdomen of first larval stage, showing spines, pores, anal tube, and stigmatal tubes; a, dorsal; b, ventral.
Fig. 21. Anal tube of fourth stage of female; a, alimentary canal; b, anterior spinnerets; c, median spinnerets; dd, posterior stigmatal tubes.

Plate XV.

Xylococcus quercus Ehrh.

Fig. 1. Leg of first larval stage.
Fig. 2. Body pores of apodous stages of female.
Fig. 3. Antenna of adult female.
Fig. 4. Leg of adult female.
Fig. 5. Body pores of adult female.
Fig. 6. Antenna of fourth stage male.
Fig. 7. Leg of fourth stage male.
Fig. 8. Body pore of fourth and fifth stages of male.
Fig. 9. Antenna of pupa of male.
Fig. 10. Leg of pupa of male.

Xylococcus alni n. sp.

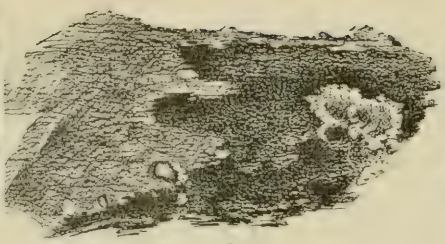
Fig. 11. Antenna of first larval stage; e, eye.
Fig. 12. Leg of first larval stage.
Fig. 13. Posterior segments of abdomen of first larval stage, showing spines, pores, anal tube, and stigmatal tubes; a dorsal; b, ventral.
Fig. 14. Anal tube of fourth stage of female; a, alimentary canal; b, anterior spinnerets; c, median spinnerets; dd, posterior stigmatal tubes.
Fig. 15. Body pores of apodous stages of female.
Fig. 16. Antenna of adult female.
Fig. 17. Leg of adult female.
Fig. 18. Body pores of adult female.



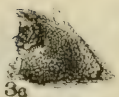
Laura Florence.



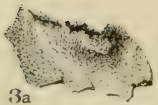
1



2



3a



3a



3b



3b



4



8



6



5a

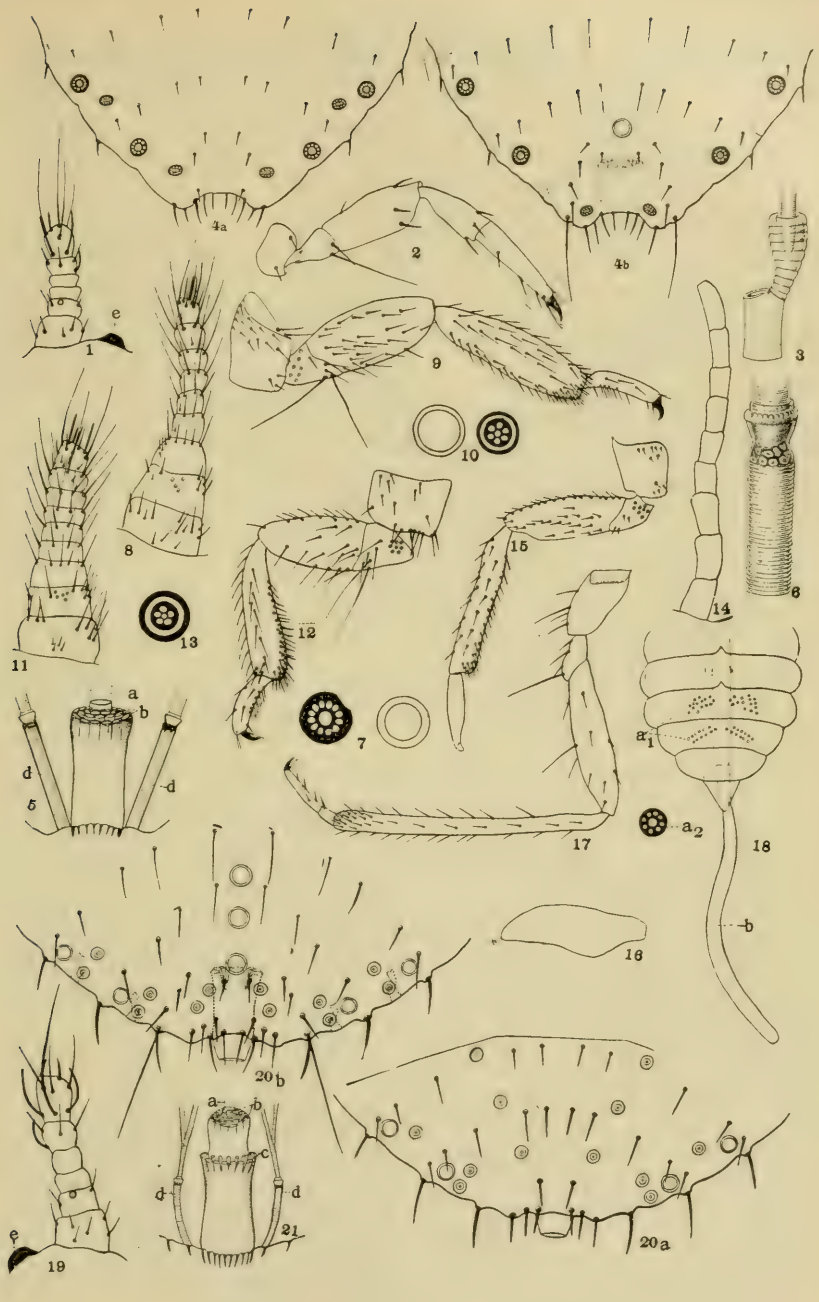


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Laura Florence.



Laura Florence.



Laura Florence.

SIX NEW SPECIES OF MALLOPHAGA FROM NORTH AMERICAN MAMMALS.

By E. A. McGregor, Bureau of Entomology.

Trichodectes kingi n. sp.

Two females (Bishopp No. 2464) from weasel, *Putorius* sp., (Florence, Mont., June 16, 1910, coll. W. V. King), female and immature specimens (Bishopp No. 3181) from weasel (Florence, Mont., April 21, 1914, coll. H. P. Wood), and five females (Bishopp No. 3219) from weasel (Florence, Mont., April 18, 1914, coll. H. P. Wood).

This species is nearest *T. retusus N.* and *T. minutus* Paine. The former is from *Mustela vulgaris* and *M. erminea*, and the latter from *Putorius noveboracensis*. It differs materially from *T. retusus* in the entire absence of spines on the dorsal portion of the abdominal segments. It differs from *T. minutus* in the more elongate head, in the absence of dorsal abdominal spines, and in the rather distinct transverse, abdominal blotches.

Description of Female.—Total length, 1.139 mm.; length of head, .305 mm.; length of prothorax, .08 mm.; length of metathorax, .059 mm.; length of abdomen, .694 mm.; width of head across temples, .32 mm.; width of prothorax, .29 mm.; width of metathorax, .36 mm.; width of abdomen, .48 mm.

Head slightly wider than long, rather abruptly narrowed anteriorly, with a very distinct median emargination, and produced into a prominent trabecula-like process just before each antenna. Antennal sinuses of considerable longitudinal span, but very shallow. Ocular projections not prominent. Temple margins diverge slightly posteriorly and meet the occipital margin without an angle. Occipital margin of one even, rotundate curve from temple to temple. Antennal bands not decidedly distinct, separated from each other anteriorly by a rather wide, clear area, continued faintly across the antennal bases to the ocular blotch which is very distinct. A small triangular, posterior-pointing flap projects dorsally at the hind end of the distinct portion of the antennal bands. Occipital bands broad and distinct at their bases, continued narrower and fainter to the ocular blotches. Underlying bands are visible, extending from the bases of the occipital bands to the mandibles. Four short hairs occur on each anterior margin between the median emargination and the trabeculæ, one weak hair arises from the eye and one immediately behind this, two long hairs at the temporal prominence, and three weak hairs between the latter and the prothorax. Antennæ of average size, about reaching the posterior margin of the head; the three segments of about equal length.

Thorax about three times as broad as long. Prothorax lenticular in outline, with the posterior margin very slightly convex. Four weak spines distributed along the lateral margin. Metathorax at first abruptly diverging, than as abruptly converging, with a wide, angulated emargination medially. A very short spine at each posterior lateral angle, a long hair just behind this, and a similar hair midway on the converging margins. Legs normal.

Abdomen subquadrate in outline, widest on the third segment. Segments 1 to 6 with rather well defined plates at the lateral borders. Each of the twelve plates with a hair near the posterior angle. First segment devoid of spines. Second segment with a spine at each lateral border. Third to fifth segments each with a lateral group of three spines. Sixth and seventh segments each with a lateral group of four spines. Eighth segment with a transverse row of six spines, and with six spines on the posterior margin—three on either side of the center. Segment eight slightly, and segment nine deeply emarginate medially. Segments two to seven each with a spiracle at the lateral margins. Transverse spines lacking on segments one to seven, inclusive.

Trichodectes floridanus n. sp.

Four females (McGregor, No. 9878) from dog, Monticello, Fla., November 26, 1913, coll. H. B. Scammell.

This species is nearest *T. latus* N., also of the dog, but is clearly distinct through the nature of the antennæ, the female appendages, the shape and markings of head, the shape of the thorax, and in the presence of the prominent spiracles on the prothorax.

Description of Female.—Total length, 1.5 mm.; length of head, .37 mm.; length of prothorax, .135 mm.; length of metathorax, .083 mm.; length of abdomen, .915 mm.; width of head between eyes, .551 mm.; width of prothorax, .405 mm.; width of metathorax, .488 mm.; width of abdomen, .811 mm.

Head just half again as wide as long, with a wide, shallow emargination anteriorly, and with the usual trabecula-like process just before each antenna. Antennal sinuses distinct, but not deep. Ocular projections distinct, but not prominent. Temporal margins commence to converge immediately behind the eyes, and meet the occipital margin with an obtuse curvature. Occipital margin rather concave for nearly the entire width of the prothorax. Antennal bands scarcely discernible, reduced to faint, linear spots at the posterior ends of the clypeal margins which are the darkest portions of the head. A crescent-shaped spot of about the color of the antennal bands occurs just inside each of the antennal sinuses. Occipital bands entirely lacking. Five short hairs occur on each of the clypeal margins, a similar hair occurs at the base of each trabecula just over which a longer hair arises, one short hair arises from each eye and one immediately behind this, two longish hairs near the temporal angle, three weak spines on each side

near the junction of the head and prothorax, and a long hair just mediad of these. Antennæ joints of nearly equal thickness, but with the third nearly equal in length to the other two.

Thorax about two and one-third times as wide as long. Prothorax rather lenticular in outline, with the median portion of the hind margin decidedly convex. A weak spine on each side at the outer ends of the anterior margin, and a stronger hair on each lateral margin just over the conspicuous, protruding spiracles, and a long hair on each side near the hind margin midway between the median line and the lateral border. Metathorax with rather abruptly converging sides, the conspicuously concave posterior margin forming nearly right angles with the lateral borders. A very short spine at each anterior lateral angle, three long hairs arising behind these so that bases form curves bending backward and inward from the spines at the angles. About eight hairs arise along the median part of the concave margin. Legs conventional.

Abdomen widely oval in outline, broadest on the second and third segments. First segment with a series of eight or nine hairs at the anterior margin medially, and with four or five spines along the lateral margin. Segments one to six, inclusive, with a stiff hair near each posterior lateral angle, and segments one to seven, inclusive, each with a transverse series of from sixteen to twenty four dorsal spines. Segments two to seven, inclusive, with a rather distinct spiracle on each lateral margin. Terminal segment rather deeply emarginate medially, with a central cluster of four dorsal spines, a transverse series of four weak spines, and a longer spine at the middle of each lateral border.

Trichodectes thomomyus n. sp.

Two females and one male (Bishopp No. 2604) from *Thomomys* sp., Jefferson, Colo., May 7, 1912, C. Birdseye, coll., and one immature specimen (Bishopp No. 2606) from the same host and locality, May 12, 1912.

This species is most nearly allied with *T. geomydis* Osb., from which it is easily distinguished by the absence of a process on the second joint of the female antennæ which are inserted before the middle of head; the straight, truncate hind margin of head; and by the shape of the metathorax.

Description of Female.—Total length, 1.111 mm.; length of head, .314 mm.; length of prothorax, .0837 mm.; length of metathorax, .0418 mm.; length of abdomen, .68 mm.; width of head across temples, .398 mm.; width of prothorax, .298 mm.; width of metathorax, .387 mm.; width of abdomen, .586 mm.

Head nearly a third again as wide as long, with a distinct, somewhat V-shaped median emargination, produced into stout, trabecula-like processes just before each antenna. Antennal sinuses only fairly deep, but of considerable longitudinal span. Ocular projections lacking. Temple margins at first are nearly parallel, but at their midpoints bend abruptly inward and meet the occipital margin at an obtuse angle.

Occipital margin almost a straight line. Antennal bands distinct, of moderate width, separated from each other at the front of head by the rather wide clear area coincident with the ample emargination at the borders of which they bend sharply backward for a short distance. Antennal bands continue clearly across the bases of the antennæ to the very distinct ocular blotches at which points they are continuous with the clearly defined occipital bands. Faint underlying bands extend from the bases of the occipital bands convergingly toward the mandibles. A broad band borders the occiput between the occipital bands. Five short hairs on each margin between the anterior emargination and trabeculæ, two on each side at the anterior border of the antennal sinus, one just within the posterior angle of antennal sinus, three longer hairs along the posterior half of temples, and eight weak spines on the dorsal surface of head. Antennæ rather stout, of three subequal joints, none of which possess a projecting process.

Thorax about three times as broad as long. Prothorax very short as compared to breadth. Sides divergent to posterior margin, which is somewhat 3-faceted. A strong spine at the posterior lateral angles and one near each end of the middle facet. Metathorax shorter than the prothorax and broader, the lateral border projecting on each side as a sharply rounding prominence, and with a wide, deep posterior median emargination. Three hairs set closely near the lateralmost portions and a transverse row of four stronger spines. Legs relatively short and stout.

Abdomen oval in outline, one-fifth longer than wide, widest on second segment. Segments one to three with pointed lateral plates which are directed inward and backward. Each lateral plate with a series of about five longish spines. First segment with two spines within the thoracic emargination, four or five short spines along the lateral margin, and a transverse series of about eighteen spines. Second segment with a series on each side—just inside the lateral plates—of about four weak spines, and a transverse row of about eighteen longer spines. Segment three with a transverse row of about seventeen long spines. Segment four with a transverse row of about thirteen spines, and on each side a series of about five spines. Segment five with about twenty-one spines in a transverse series. Segment six with a transverse series of about thirty spines. Seventh segment with three long spines at each posterior lateral angle, and a series of four placed medially. Segment eight with a transverse series of six long spines. Terminal segment subconical, sharply emarginate, and with four slender hairs subterminally. Seventh segment with a pair of chitinized, lateral female appendages.

Head of male a trifle wider relatively than that of female; anterior emargination deeper and more acute; antennal sinuses deeper; anterior angle of temple much more rounded; occipital margin somewhat concave.

Trichodectes monticolus n. sp.

Six females and two males (Bishopp No. 6837) from skunk, Topaz, Calif., September 15, 1916, coll. J. L. Webb.

This species, from the California Sierras, is nearest *T. mephitidis* Osb. from which it differs as follows: FEMALE.—A fairly well-developed angle at point of junction of temples with occiput; hairs on front of head; lateral borders of metathorax strongly converging, posterior border widely and deeply excavated. MALE.—Frontal emargination represented merely by a transparent spot; antennæ with basal joint not greatly longer than third, a pair of angulated processes on the basal and second joints at the dividing suture which are opposed to one another, terminal joint with a blunt spur on posterior margin near base; antennal sinuses more deeply excavated; temporal lobes more prominent.

Description of Female.—Total length, 1.07 mm.; length of head, .313 mm.; length of prothorax, .062 mm.; length of metathorax, .038 mm; length of abdomen, .665 mm.; width of head across temples, .380 mm.; width of prothorax, .280 mm.; width of metathorax, .313 mm.; width of abdomen, .541 mm.

Head about one-fifth wider than long, rather generally rounded anteriorly, with a small but distinct median emargination, and with the usual trabecula-like flaps before each antenna. Antennal sinuses rather shallow. Ocular projections prominent. Temporal margins parallel one another for a short distance behind eyes, but soon converge to meet the occipital margin at an obtuse angle. Starting at these angles the occipital margin on either side first curves inward and then bends back again to form a strong median convexity. Antennal bands rather broad and very distinct, anteriorly bending abruptly at an acute angle to form expanded, backward-pointing bars which inclose a clear area behind the emargination, and continued distinctly across the antennal bases to the well-defined ocular blotch. A semicircular, hyaline flap projects backward, dorsally, just within that portion of the antennal bands lying abreast of the trabeculæ. Occipital bands at their bases broad and distinct, continued narrower and fainter about half way to the ocular blotches. Underlying bands are visible extending from the bases of the occipital bands to the mandibles. Five weak hairs occur on each anterior margin between the frontal emargination and the trabeculæ, one weak hair arises from the rear of the eye, five short hairs occur along the temporal margin, and one long hair arises on each side at the temporal-occipital angle. Antennæ of average size, the last joint the longest, but with no marked difference between them.

Thorax three and one-third times as wide as long. Prothorax sub-rectangular, with posterior margin slightly convex. A weak spine

at the posterior lateral angle, another just within the anterior angle, and a long spine arises on each side midway to the center. Metathorax at first abruptly diverging for a very short distance, and then as abruptly converging with a concave-bordered excavation medially. A short spine at the lateralmost points, three long spines along the converging sides, and eight longish spines along the border of the emargination. Legs normal.

Abdomen oval in outline, widest on the third and fourth segments. First segment with six short spines along each lateral margin, a series of eight across that part within the metathoracic excavation, and about twenty-two in a transverse series along the hind margin. Segments two to seven, inclusive, with transverse rows of spines as follows: Segment two, twenty-six spines; segment three, twenty-seven spines; segment four, twenty-two spines; segment five, eighteen spines; segment six, twenty spines (of very uneven length); segment seven, fourteen spines. Segment eight with a long hair within each of the chitinized appendages (arising from the seventh segment), and two weak hairs near the posterior tip.

Male.—Head one-third again as wide as long; antennal sinuses much deeper than those of female, and are nearly filled by the ample trabecula-like processes; temples narrower but more prominent; anterior median emargination represented merely by a transparent V-shaped spot. Antennæ with basal joint swollen; a pair of pincer-like processes on the basal and second joints opposed to one another across the dividing suture; last joint with an obtuse-angled spur on inner margin near base.

Trichodectes scleritus n. sp.

Numerous females and immature individuals (McGregor No. 4321) from gopher, Florida.

This species is somewhat intermediate between *T. geomydis* Osb. and *T.* californicus Chapm., probably nearest the former as figured by Kellogg and Ferris. Very distinct through the following characters: Hooked trabeculæ; presence of posterior prominence on second and third antennal joints; conspicuous lateral sclerites on first to fifth abdominal segments, inclusive.

Description of Female.—Total length, 1.04 mm.; length of head, .284 mm.; length of prothorax, .092 mm.; length of metathorax, .042 mm; length of abdomen, .625 mm.; width of head across temples, .412 mm.; width of prothorax, .298 mm.; width of metathorax, .341 mm.; width of abdomen, .575 mm.

Head almost half again as wide as long, generally rounded anteriorly with a conspicuous, semicircular median emargination, and produced into a hooked trabecula-like appendage at the base of the antennæ. Antennal sinuses moderately deep and wide. . Ocular projections not very prominent. Temple margins diverge little, and soon curve convergingly to meet the occipital margin, forming with it rather

prominent lobes. Occiput very slightly convex. Antennal bands not very distinct, separated from one another anteriorly by the ample emargination at the sides of which they bend abruptly backward as darker bars; continued faintly across the antennal bases to the fairly distinct ocular blotch. Occipital bands barely discernible, paling to invisibility half way to the ocular blotches. Underlying bands are seen extending from the bases of the occipital bands to the base of mandibles at which point occurs on each side a small dark blotch. Three hairs arise from the front margin on each side of the median emargination, two arise midway to the trabeculæ, three just before the antennæ, two on each side from clear areas just within the clypeal margin, a hair arises from the eye, four occur along the temple, one at each lateral end of the occipital margin, and six weak hairs occur near the central portion of the dorsal aspect. Antennæ of generous dimensions, the second and third joints with posterior prominences.

Thorax two and two-thirds as broad as long. Prothorax trapezoidal, the sides diverging posteriorly, with slightly convex posterior margin. A short spine at the posterior lateral angle, and four weak hairs near the middle. Metathorax with conspicuous lateral extensions, then abruptly converging to the evenly concave posterior margin. Two shortish spines on the lateral wings, a long hair just behind these, and a transverse series of six long hairs. Legs about as usual.

Abdomen oval in outline, widest on the third segment. Segments one to five inclusive with conspicuous lateral plates. Plates I with three marginal spines and one dorsal spine; plates II with two marginal and three dorsal spines; plates III with three marginal and two dorsal spines; plates IV with three marginal and one dorsal spine; plates V with three long submarginal hairs. Segment one with two median spines just behind the thoracic border, and with a transverse series of about eleven spines. Segment two with a transverse series of about fourteen spines. Segment three with a transverse series of about eighteen spines. Segment four with a transverse series of about seventeen spines. Segment five with about fifteen spines in a transverse series. Segment six with a transverse row of about seventeen spines. Segment seven with four long hairs near the posterior lateral angle and two near the middle. Segment eight with a lateral series at each side of three spines each just within the female appendages, and with six weaker ones near the notched tip.

Trichodectes odocoilei n. sp.

Three females (Bishopp No. 2468) from White-tailed deer (*Odocoileus virginianus macrourus*), Lolo Hot Springs, Mont., June 23, 1910, coll. W. V. King.

This species agrees fairly well with *T. tibialis* Piag. as figured by Morse and by Osborn, but it is very distinct from the original description and figure of Piaget, especially in the following characters: Point of insertion of antennæ; front of

head not with "multitude" of hairs as Piaget states for tibialis; shape of thorax (especially metathorax); general outline of abdomen; character of abdominal blotches; the distribution of dorsal spines; and in the markings on the eighth and ninth abdominal segments.

Description of Female.—Total length, 1.72 mm.; length of head, .492 mm.; length of prothorax, .102 mm.; length of metathorax, .102 mm.; length of abdomen, 1.025 mm.; width of head across temples, .471 mm.; width of prothorax, .369 mm.; width of metathorax, .430 mm.; width of abdomen, .533 mm.

Head slightly longer than wide, unusually elongate, truncate anteriorly by a wide, shallow emargination, and produced into the trabecula points just before the antennæ. Antennal sinuses shallow. Ocular projections quite noticeable. Temple margins at first parallel one another, then curve abruptly inward to the occipital margin with which they do not form angles. The occiput is nearly straight, but slight emarginations occur just mediad of the bases of the occipital bands. Antennal bands broad and distinct, bending abruptly inward just before the bases of the antennæ and not continued to the inconspicuous ocular blotch, bent directly backward at the lateral angles of the anterior emargination, forming bars which reach to the mandible bases. A backward-pointing triangular plate which is narrowly cleft to the apex fills the space between the truncated front and the mandibles. Occipital bands narrow and faint, paling before reaching the antennal bands. Between the bases of the occipital bands are a pair of sharply recurved blotches. Two short hairs occur on the truncate front, two at each of the frontal angles, seven along the outer margin of the antennal bands, five on the temples, eight in a curving row in front of the mandibles, and a dozen disposed dorsally on the posterior half of the head. Antennæ long, slender, the second joint the longest, the third slightly curving.

Thorax twice as broad as long. Prothorax roughly rectangular, with posterior margin slightly convex with a weak median concavity. A conspicuous spiracle at each lateral border. A weak spine just before each spiracle, a similar one at each posterior lateral angle, and a pair near the middle of the segment. Metathorax with sides first diverging and ten parallel, posterior margin running slightly forward to form an obtuse-angled emargination. A short spine at each posterior lateral angle, and ten along the posterior border of which four are long and six short. Legs conventional.

Abdomen with sides sub-parallel, widest on third segment. Segments two to seven, inclusive, with conspicuous lateral spiracles. Segments one to seven, inclusive, with dusky, transparent blotches which are separated from the lateral bands of similar color by narrow, clear spaces. Segment eight with a pair of smoky, elliptical blotches. Segments one to six, inclusive, with a short hair in front of the posterior lateral angles; segment seven with a longer hair at the angles. Seg-

ments one to seven, inclusive, each with a transverse series of short spines as follows: Segment one, seventeen spines; segment two, twenty-one spines; segment three, seventeen spines; segment four, sixteen spines; segment five, sixteen spines; segment six, eighteen spines (two at each side longer); segment seven, ten spines (one at each side longer). The eighth segment with a transverse series of six spines, the outer two of which are long, and with four arising at the tip which is sharply notched. All of the abdominal spines arising from clear pustulations.

EXPLANATION OF PLATES.

Plate XVI.

Fig. 1. Female of *Trichodectes monticolus* n. sp.
Fig. 2. Head of male of *Trichodectes monticolus* n. sp.
Fig. 3. Left leg III of female of *Trichodectes floridanus* n. sp. (viewed ventrally).
Fig. 4. Left leg III of female of *Trichodectes monticolus* n. sp. (viewed ventrally).
Fig. 5. Female of *Trichodectes floridanus* n. sp.
Fig. 6. Antenna of male of *Trichodectes monticolus* n. sp.

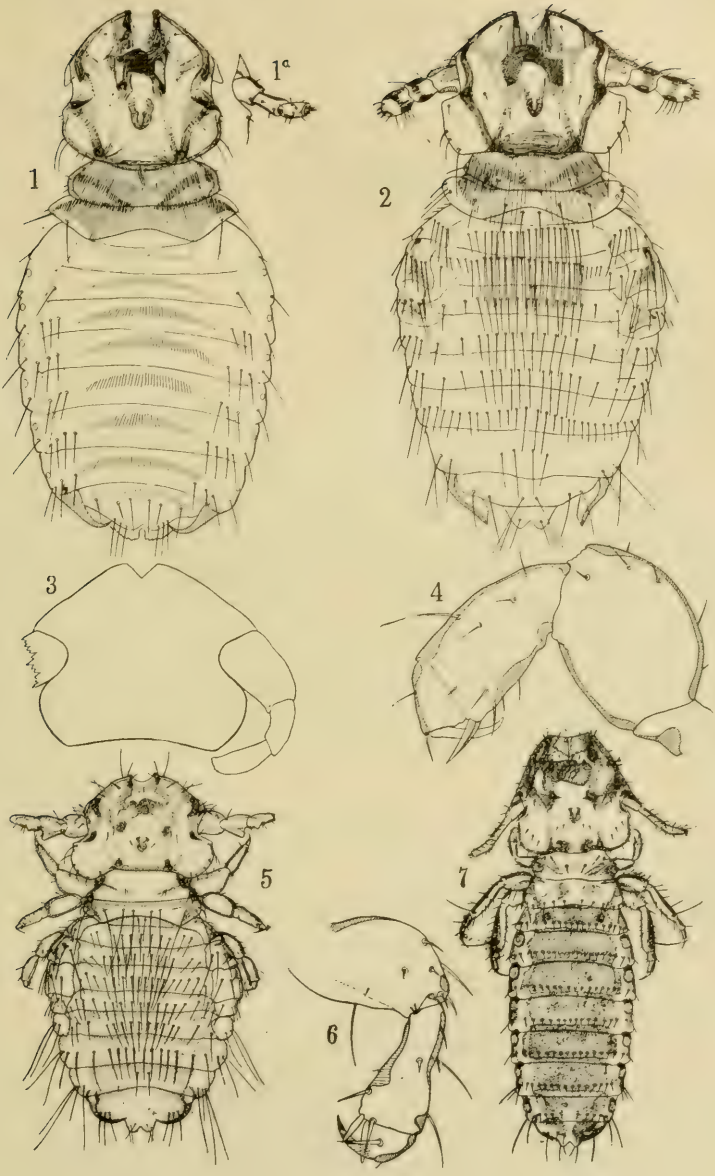
Plate XVII.

Fig. 1. Female of *Trichodectes kingi* n. sp.
Fig. 1a. Antenna of female of *Trichodectes kingi* n. sp.
Fig. 2. Female of *Trichodectes thomomyus* n. sp.
Fig. 3. Head of male of *Trichodectes thomomyus* n. sp.
Fig. 4. Right leg III of female of *Trichodectes thomomyus* n. sp. (viewed ventrally).
Fig. 5. Female of *Trichodectes scleritus* n. sp.
Fig. 6. Right leg II of female of *Trichodectes kingi* n. sp.
Fig. 7. Female of *Trichodectes odocoileis* n. sp.

The drawings have been made through the employment of the camera lucida with little attempt to restore symmetry.



E. A. McGregor.



E. A. McGregor.

HIBERNATION: A PERIODICAL PHENOMENON.

By J. P. Baumberger, Bussey Institution.

Hibernation may be defined as the quiescent condition characteristic of many organisms during winter. A number of investigators have studied the phenomenon for the plant and animal kingdoms and have assembled a large mass of facts as to the physiological conditions and the habits of hibernating organisms. The studies have also included the causes of this quiescence and a number of hypotheses have been proposed.

Confining ourselves to insects the most commonly proposed hypothesis is that low temperature or low mean temperature is conducive to hibernation. In a previous paper[1] the author analysed an amount of temperature data with reference to the date of hibernation of the Codling Moth and showed that in the cases studied a marked lowering of average temperature or a very low temperature did not immediately precede the date of hibernation. The author has during the past two years carried on some experiments with the banana fly (*Drosophila melanogaster* Meigen) with the object of determining whether or not a hibernating period could be established by the stimulus of low temperatures. In this experiment eggs, larvæ, pupæ and adults of the same parents were kept in the ice box and in the greenhouse.

TABLE I.

Pupal Period.

Number Pupæ	Number Days in Ice Box	Temp.	Number Days in Greenhouse	Temp.
370	10	41-43° F.	8.43	58-86° F.
340	0	41-43° F.	9.09	58-86° F.

The proceedure was as follows: pupæ were placed in the ice box for ten days and then removed to the green house. At the date of removal pupæ which had just formed were also placed in the greenhouse. The periods of time that elapsed before emergence of the adults was then compared. The results show

that a persistent quiescent condition was in no case brought about by this treatment. Larvæ and adults after twenty days in ice box were immediately activated by high temperature.

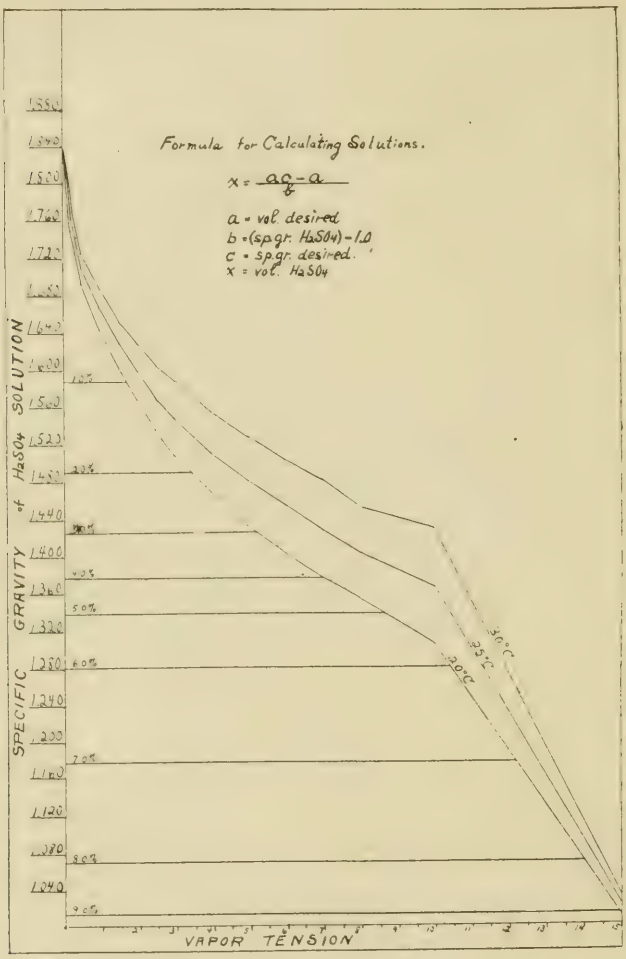


FIGURE 1

In order to avoid confusion it would be well to state, at this point, that in general hibernation in insects is characterized by quiescence which persists for sometime after the temperature has risen or continues through periods of high temperature. In many cases the phenomenon manifests itself before the temper-

ature falls. In this case the condition can be recognized by a pause in feeding and in growth. The Codling Moth has already been cited as an example of this peculiarity. It might also be said that the food of the insect has not become less available at this period. Other common insects which hibernate as larvæ at a definite date irrespective of low temperatures are the Woolly Bear (Isia isabella) and an Arctiid (Apantesis nais). This "habit" was studied in 1915, especially with reference to its independence of stimulii from relative humidity.

The proceedure was as follows: Different relative humidities were maintained by solutions of H_2SO_4 of various sp. gr. as suggested by Woodworth[2] and which I calculated from figures given by Richards.[3] I have plotted the curve below from Richard's figures and used the formula accompanying it in the Volume calculations. (Figure 1).

The solutions (200 cc.) were placed in battery jars (capacity 2000 cc.) with broad ground edges, which were vasalened and covered with a glass plate. Inside these battery jars, supported over the H_2SO_4 by square glass dishes, were placed glass jars with a covering of cloth net in which the caterpillars were kept. Food was introduced daily into the jar and the sulphuric acid solution was changed every two weeks. The effects of different humidities was very apparent on the food introduced. In this work, due to the variation in temperature the humidity of any bottle also varied, but this change being equal in each bottle, the difference between bottles remained uniform. The moisture absorbed from food and insects by the H_2SO_4 is a source of error but not a great one.

The data derived from these experiments are shown in tables II and III.

TABLE II.

APANTESIS NAIS.

No. of Experiment..	9	11	12	13	14	15	16	17	27
Date.....	x/7	x/7	x/7	x/7	x/7	x/7	x/7	x/7	x/7
Number Specimens..	10	10	10	10	10	10	10	10	10
Vapor tention..... (15.=saturation)	9.	15.	5.6	13.5	11.	.5	13.8	.8	1.8
No. molted skins....	13	15	12	10	8	10	14	8	8
Date stopped feeding	x1/1	x1/4	x1/4	x1/29	x1/16	x/18	x1/4	x/16	x/16
Date of first death..	x1/1	x1/1	x/14	x11/2	x1/4	x/14	x/4	x/14	x/14
2nd Humidity..... (vapor tention)	13.8	5.6	15.	15.	15.	15.	5.6	15.	
Date.....	x1/11	x1/11	x1/11	x11/4	x1/27	x/18	x1/11	x/18	
Eating.....						x 18		x/18	
Molts.....						1		1	
Date Death.....	x1/20	x1/11	x1/16			x/21	x1/16	x/21	
Date not Eating....						x1/27		x1/4	

TABLE III.

III–38. Sixteen specimens of Isis isabella caterpillars.

DATE	VAPOR TENTION	BEHAVIOR
x1/20–x1/27	15.0	not eating, 1 molt.
x1/27–x1/29	9.0	" " 0 "
x1/29–x11/2	13.5	" " 0 "
x11/2–x11/7	15.	" " 0 "
x11/7–x11/9	13.8	" " 0 "
x11/9–x11/11	13.8 15.0	" " 0 "
x11/11.....		First Death.

Table III shows a great regularity in the date at which the caterpillars at the different humidities ceased feeding. This date can be considered as the beginning of hibernation, as no feeding took place later than this and all molting and metamorphosis ceased. Since these larvæ were exposed to a high temperature and had abundant fresh food present it is apparent that high temperature, abundant food and any relative humidity is not sufficient stimulus to overcome the "tendency" of the

insects to hibernate. Table IV gives further support to this conclusion and also indicates that various successive treatments with different humidities are also of no avail. Death was not due to poisoning of the larvæ by fumes given off from H_2SO_4, for *Noctua unipuncta* moths were reared from first stage larvæ at vapor tentions 3.4, 9.0, 11., 13.5, 15.0.

Since larvæ before experiencing winter go into a hibernating condition from which various combinations of the three stimulii high temperature humidity and food cannot "arouse" them, we must conclude that this quiescence is predetermined. The practice of collectors and the experiments of Weissmann,[4] have shown that a period of low temperature makes it possible to activate hibernating insects by high temperature. Kirby and Spence[5] have suggested that this predetermination is instinctive as they observed that before winter insects suddenly at a definite date, independent of weather conditions, start an excited search for winter shelters. This "instinct" has probably been noticed by every collector of insects. However, this "instinct," if not directed by any external stimulus is rather hard to explain in cases where a summer and a winter generation occur.

Pictet[6] studied the *Lasiocampa quercus* and Dendrolimus larvæ which hibernate before the temperature has lowered. In the case of *Lasiocampa quercus*, the adult emerges in July, but larvæ appear in August and hibernate, beginning again to develop in Spring and pupating in June-July. By keeping the larvæ on ice it was possible to cause them to pupate in May. Continued selection of precocious larvæ for six generations decreased the length of larval life from 245 to 112 days. The pupal period was lengthened sufficiently to make up for the difference. Similar experiments with *Dendrolimus pini* gave a second generation and no persistence of the normal cycle. Pictet believes that this difference is due to the fact that *Lasciocampa quercus* feeds on the leaves of deciduous trees, while *Dendrolimus pini* feeds on the leaves of evergreen trees.

We have seen that certain insects have a definite periodical hibernation which is hereditary. This quiescence can only be overcome by a certain period of low temperature and the organisms then by a compensatory lengthening of the next stage regains its normal rhythm. Other insects are more plastic and instead of showing a definite period of hibernation, merely remain quiescent during periods of low temperature and

are active immediately after the temperature is raised. Such insects can be reared all the year round in the greenhouse and may be exemplified by Drosophila, *Noctua unipuncta*, the cockroaches, *Musca domestica* and others. In fact, we have every degree of development of this periodicity.

The factors which have determined the variability of this characteristic may be seen from a survey of some insect life histories. These factors are of three kinds:

1. *Climate.*—As there is no cold period in the tropics, insects do not hibernate there. This lack of periodicity persists in insects introduced into the temperate regions. This is probably the case with Drosophila which cannot be induced to hibernate.

2. *Food.*—Insects which feed upon materials constantly available do not show a definite periodicity. Thus the house fly female will oviposit at any time of the year when the temperature is appropriate. Pictet has pointed out that insects which feed on evergreen trees are not as rhythmical in their hibernation as those which feed on deciduous trees.

3. *Exposures.*—The degree to which insects are each year exposed to the conditions of winter may also determine the elasticity of their periodicity. Thus the Woolly Bear, which hibernates under stones in rather an exposed condition, has a definitely established period of hibernation, whereas the Army Worm, which hibernates deep in the earth, is less exposed to the effects of winter and hence hibernates only upon direct stimulus.

These three factors may also determine the stage or stages in which different species of insects hibernate. The data on life histories contained in Judeich and Nitsche[7] are more available than any others, because the life cycles of different species are tabulated in a system of which I show a modification below. This method makes it possible to record scattered observations on different stages of the life cycle of an insect and finally to read the whole history at a glance. It would be a great advance if a repository for such data could be established at some university or other institution.

LEPIDOPTERA *Phycis tumidella* Zk.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
EEE	EEE	EEL	LLL	LLL	PPP	AAA	EEE	EEE	EEE	EEE	EEE

Dist.—Mid. Europe, S. France.
Larvæ—Skeletonize oak leaves, from one side only, working in a tunnel under roof of pcs. of leaves.
Pupæ—In cocoon under ground.
Judeich u. Nitsche, 1895, p. 1060.
Symbols A, E, L, P stands for adult, egg, larva and pupa respectively.

HYMENOPTERA *Lophyrus pini* L.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
ppp	ppp	ppP	AA EE PAA	*LLL*	*LLL*	PPA E	A E*LL*	*LLL*	*L*pp	ppp	ppp
ppp	ppp	ppP	AA EE EE PAA EE	LLL LLL 1	LLL LLL	ppp PPA E	ppp A 2 ELL	ppp LLL	ppp Lpp	ppp ppp	ppp 1 ppp 2'
ppp	ppp	ppP	PAA	2'							

Symbols as above with addition of "p" for prepupa and numbers for alternating generations and *italicized* to indicate injurious period.

This method of tabulation is more easily read and used than the system sometimes employed by the U. S. Bureau in which a circle represents the whole year and different stages occupy sectors or are shown by spiral lines. In a life cycle that extended over several years, such a method would lead to endless complications.

For the Tortricids of European forests we find by compilation that those species which feed on the outside of the tree hibernate in a resistant stage that is, as eggs or pupæ—whereas those which feed on the inside (protected places) of the tree hibernate as larvæ.

TABLE IV.

SPECIES	FEEDING HABIT	HIBERNATING STAGE
Tortrix		
pinicolana Zll.	Outside on needles of Larch	Egg
murinana Hbn.	Outside on needles of White Fir	Egg
rufimitrana H.Sch.	Outside on needles of White Fir	Egg
viridana L.	Outside on leaves of Oak	Egg
buoliana Schiff.	Inside bud of Pine	Larva
nigricana H. Sch.	Inside bud of Fir	Larva
tedella Cl.	Inside needles of Pine	Larva
duplicana Zett.	Inside twigs of Pine	Larva
pactolana Zll.	Inside twigs of Pine	Larva
turionana Hbn.	Inside buds of Scotch Fir	Larva
strobilella L.	Inside cones of Pine	Larva
resinella L.	Inside bud *gall* of Pine	Larva, two years
zebeana Ratz.	Inside resinous gall of Larch	Larva, two years
duplana Hbn.	Outside on shoots of Fir	Pupa

Again compiling the data on the Noctuidæ from the same source similar results are obtained and it is also shown that food supply is a factor in the determination of the hibernating stage.

TABLE V.

Noctuidæ.

HIBERNATING STAGE					LARVAL FOOD HABIT
Any stage	Egg	Larva	Pupa	Imago	
1			1	2	Polyphagus
	3		4	1	Desciduous trees
			1		Evergreen trees
	1				Borer
		2			Underground

Compiled from life-histories of the following species:

Noctua satellitia L.
Noctua exolitia L.
Noctua piniperda Panz.
Noctua aprilina L.
Noctua ochracea Hbn.
Noctua segetum Schiff.
Noctua coryli L.
Noctua incerta Hfn.
Noctua vetusta Hbn.
Noctua pisi L.
Noctua gamma L.
Noctua trapezina L.
Noctua caeruleocephala L.
Noctua vestigealis Rott.
Noctua aceris L.
Noctua pulverulenta Esp.

In general, we may conclude that insects hibernate as (1) adults, when their food habits are such that oviposition can take place on the proper food at the earliest warm weather (2) as larvæ, when protected from the cold and thus able to continue feeding to the latest date possible, (3) as pupæ or eggs, because they are nonfeeding resistant stages.

There is no evidence available as to whether or not these adaptations were established by selection, mutation, or inheritance of acquired characters. The evidence does, however, show that hibernation has resulted from the repeated effect of winter upon the species and that the degree to which this phenomenon has become rhythmical has been determined by the habits of the insect.

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THE NATURE OF THE VERACERVIX OR NECK REGION IN INSECTS.*

By G. C. Crampton, Ph. D.

Occasional references to the neck as the "labial or microthoracic segment" in recent entomological literature indicate a tendency to revive the old mistaken conception of the neck region of insects as representing the labial segment, or a vestigial segment of the thorax ("microthorax")—a view which dates from the time of Strauss-Duerkheim, 1828, and Huxley, 1885, but for which no real evidence has ever been adduced. It is a simple matter to demonstrate (1) that the neck region is in every way homologous with the other *intersegmental* regions between the true thoracic segments, and therefore cannot represent a segment at all; (2) that like the other intersegmetal regions with which it is homologous, it has no ganglia or any other segmental structures, either in the adult or embryonic stages; (3) that the labium is not its appendage; and (4) that there is already present in the head capsule a labial segment forming that portion of the head region to which the labium is articulated, while the labium is not articulated to the neck plates at all, the latter being formed behind the true labial segment. If these facts were known, there could be no excuse for arbitrarily designating the neck plates as "the labial or microthoracic segment," without giving any reason for justifying such a course of procedure, in the face of the overwhelming evidence that the neck region does not represent such a segment at all; so that it may perhaps be worth while to present the evidence which completely disproves the view that the neck region is a segment either labial or "microthoracic."

The evidence to be adduced from comparative anatomy in regard to the *intersegmental* nature of the neck plates, is most convincing and conclusive. In Fig. 1 the intersegmental plates located in the intersegmental regions designated as "Int" (i. e. regions I, III and V) are shaded so as to enable one to compare them more readily in the different segments, the entire figure being a composite of the conditions found in the most primitive of the Apterygotan and Pterygotan

*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass.

insects. It is at once apparent from a glance at Fig. 1, that the two ventral prothoracic intersegmental plates designated as "*ps*" in intersegmental region I (i. e. "Int. I") are in every way homologous with the two ventral metathoracic intersegmental plates designated as "*ps*" in intersegmental region V (i. e. "Int. V"). In the Plecopteron *Capnia* (Fig. 1) there are two ventral prothoracic intersegmental plates "*ps*" in intersegmental region I, but in the closely related Plecopteron *Leuctra* (Fig. 3) the anterior one of the two ventral prothoracic intersegmental plates "*ps*" has almost disappeared in region I, while

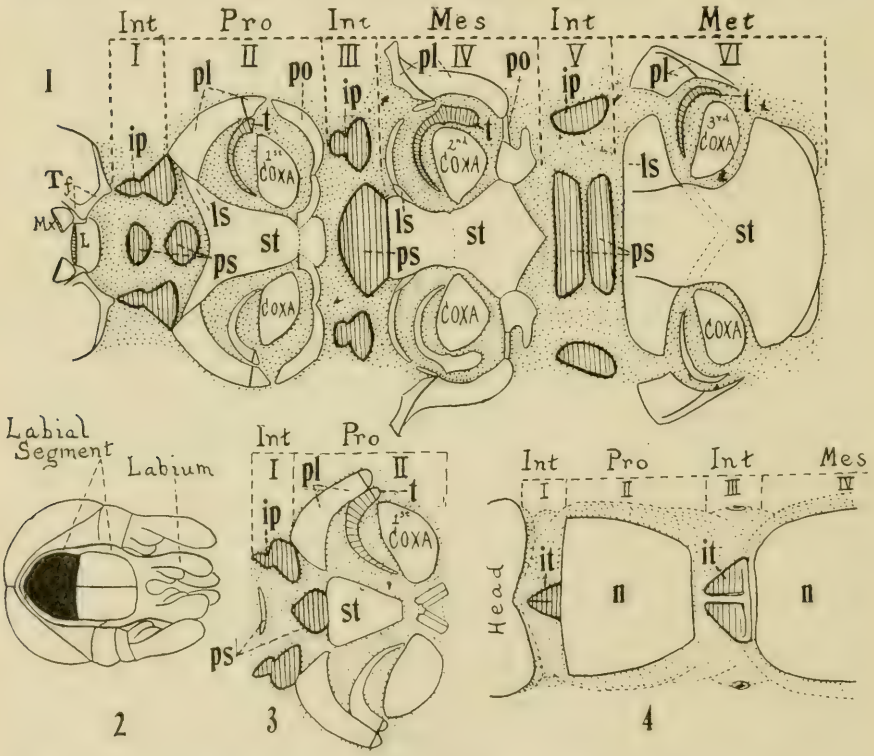


Fig. 1. Lateral and ventral region of the prothorax of **Capnia,** the mesothorax of **Eosentomon,** and the metathorax of **Japyx** drawn as though spread out in one plane. Based, in part, upon figures by Prell, 1913, and Verhoeff, 1904.

Fig. 2. Head of an embryo of **Eutermes,** stage "F," taken from Fig. 28, Plate 3, of paper by Holmgren, 1909. (Figure slightly modified).

Fig. 3. Lateral and ventral regions of prothorax of **Leuctra,** drawn as though spread out in one plane.

Fig. 4. Dorsal view of prothorax and mesothorax of **Japyx,** based on figures from various sources.

the posterior one, "*ps*," is still large, and is connected with the sternal plate "*st*" behind it, as is the case with the ventral mesothoracic intersegmental plate "*ps*" of intersegmental region III, in Fig. 1. It is thus a very simple matter to homologize the ventral prothoracic intersegmental plates "*ps*" (i. e. the neck plates) of intersegmental region I of Figs. 3 and 1, with the ventral mesothoracic and metathoracic intersegmental plates "*ps*" of intersegmental regions III and V, (Fig. 1). In the same way, the lateral prothoracic intersegmental plates "*ip*" of region I are homologous with the lateral mesothoracic and metathoracic intersegmental plates "*ip*" of regions III and V (Fig. 1). Similarly, the tergal prothoracic intersegmental plates "*it*" of intersegmental region I (Fig. 4) are homologous with the tergal mesothoracic (and also with the tergal metathoracic) intersegmental plates "*it*" of intersegmental region III, etc. (Fig. 4).

It is thus a very simple matter even for the veriest tyro in the study of comparative anatomy to homologize intersegmental region I (i. e. the neck region) with intersegmental regions III and V (Figs. 1, 3 and 4), and if comparative morphology has any meaning at all, intersegmental regions III and V

ABBREVIATIONS.

Int—Intersegmental regions between labial segment and prothorax; between prothorax and mesothorax; and between mesothorax and metathorax.
ip—Interpleurites, or lateral intersegmental plates.
it—Intertergites, or dorsal intersegmental plates.
L—Labium.
ls—Laterosternite, or lateral plate of sternum.
Mes—Mesothorax.
Met—Metathorax.
Mx—Maxillae.
n—Notum or tergum.
Pro—Prothorax.
pl—Pleural plate (Eupleuron).
po—Post-coxal plate (Postcoxale).
ps—Intersternites or sternal intersegmental plates, the posterior one being the presternite.
st—Sternum.
t—Eutrochantin.
Tf—Trophifer, or sclerite to which labium and maxillae are articulated.
I—Veracervix, or prointersegment, the first intersegmental region which is largely prothoracic.
II—Remainder of prothorax.
III—Mesointersegment, or second intersegmental region which is largely mesothoracic.
IV—Remainder of mesothorax.
V—Metaintersegment.
VI—Remainder of metathorax.

must also be considered as representing entire segments, if their homologue, intersegmental region I, is taken to represent a distinct segment. Verhoeff, 1902-1903, clearly realized that it was impossible to consider intersegmental region I (i. e. the neck) as a distinct segment, without likewise regarding its homologues, intersegmental regions III and V, as representing entire segments also, since all three regions are in every way exactly homologous. Verhoeff, 1904, therefore boldly accepted the consequences of his assumption, and claimed that the thorax actually consists of six segments, terming the intersegmental regions the "microthorax, stenothorax and cryptothorax," and making them the equivalents of the prothorax, mesothorax and metathorax. Embryology, however, affords no evidence of more than three segments in the thorax, nor does the evidence of comparative anatomy give any grounds for considering that these intersegmental regions represent distinct segments, since none of them contains any ganglia or other segmental structures—as was pointed out by Silvestri, 1902, Boerner, 1903, Desguin, 1908, and others—and no recent entomologist has had the courage to claim that the thorax is composed of more than three segments.

Some entomologists, however, ignoring the fact that intersegmental region I (Figs. 1, etc.) is in every way homologous with intersegmental regions III and V, would maintain that intersegmental region I (i. e. the neck region) *alone* represents a distinct segment, claiming that it is the real labial segment. Since the labium ("L" of Fig. 1) does not articulate with the plates of intersegmental region I, but articulates with the sclerite designated as "*Tf*" (which contains the real labial segment) in the head capsule, these entomologists are forced to the astonishing conclusion that the labium has become detached from its own segment, and, taking along with it the labial neuromere (or labial ganglion) and other characteristic segmental structures, has migrated "bag and baggage" into the head region, leaving behind it the mere shell of the labial segment in the neck region I! Such a disruption and migration of both internal segmental structures and external appendages, which have in some way become detached from their proper segment, and have grafted themselves onto another region, is wholly without precedent in the entire realm of Zoology, for never did such an occurrence take place other than in a labora-

tory grafting experiment, and the mechanism for its accomplishment in nature is utterly incomprehensible. What advantage can there possibly be in rejecting the perfectly obvious, simple and logical explanation of the neck plates as an intersegmental region, similar in every way to the other intersegmental regions of the thorax, and in the place of such a simple explanation, proposing that an unparalleled and unprecedented disruption and grafting experiment has taken place in the labial region alone in all nature, when we know of absolutely no mechanism by which such an operation could be carried out? Always, in the cephalization process, both segment and appendage enter into the composition of the head region, although the appendage may subsequently degenerate, and the segment may become indistinguishably fused with the other segments forming the head capsule.

Since the labium articulates with the head capsule, it is but natural to suppose that the segment which originally bore the labial appendage is included in that region of the head capsule with which the labium articulates, and embryology fully justifies this assumption. As is shown in Fig. 2, which I have adapted from a figure of the embryological development of the head of a Termite by Holmgren, 1909, the entire labial segment of these insects actually enters into the composition of the head capsule of the developing Termite, and does not remain behind to form the neck plates, while its appendages become disrupted and graft themselves upon the head capsule. Furthermore, the neck plates are unusually well developed in the Termites (which are quite closely related to the Blattids), and if these neck plates really represent the labial segment, the fact would be clearly indicated in the development of these insects; whereas, on the contrary, the researches of Holmgren, 1909, and Heymons, 1895-1905, carried out upon a great range of embryos of very primitive insects, conclusively demonstrate that the labial segment enters into the composition of that portion of the head capsule to which the labium is articulated, and which one would naturally expect, from the manner in which all other appendages are articulated to the segment which originally bore them, instead of unnaturally grafting themselves upon some other region!

On this account, I am inclined to regard as a "*lapsus calami*" the including of the neck plates in the labial segment

by Riley, 1904, in his table of the parts of the head of a Blattid embryo. Riley offers absolutely no proof whatsoever, either in his text or figures, for such an assumption, and it is the more inexplicable from the fact that he definitely states that the "pleurite" (i. e. the embryologists' term for pleuron) of the labial segment is in the posterior portion of the embryo's head capsule. The only explanation which suggests itself, is that he must have been unaware of the existence of intersegmental regions III and V (Fig. 1), homologous with the neck plates, and situated between the true segments, in the lower insects, and was thus unable otherwise to account for the presence of the intersegmental plates forming the neck region, unless they were to be regarded as representing the labial segment. Since I have not examined Dr. Riley's material, I do not know what evidence it offered for assuming that the neck plates represent the embryonic labial segment, but, while studying in Berlin, Prof. Heymons allowed me to look over his embryological material, in which I was unable to find any indications whatsoever that the neck plates represent the embryological labial segment; and in view of the direct embryological evidence that the labial segment is included in that portion of the head capsule to which the labium is articulated, I am forced to consider that the including of the neck plates in the labial segment in Dr. Riley's paper, is a minor error in an otherwise extremely carefully conducted and valuable embryological investigation.

I have perhaps laid too great emphasis upon a "side issue" of Dr. Riley's paper simply because, in searching through the appended list of reference works, his is the only recent article I could find, containing original embryological data, in which the neck plates are referred to as the labial segment; and on this account, I have inferred that recent investigators have reference to his work, when they state that there is embryological "proof" that the neck plates are to be regarded as the "labial or microthoracic segment." It seems incredible that any one can seriously put forth as "proof" the mere fact that some investigator has arbitrarily designated the neck plates as the labial segment in his table of the parts of the head, without giving any reasons for so doing, but such seems to be the case, unless these entomologists have reference to some other work which I have not seen.

Now the neck region of an insect is no more a part of the head capsule than the seven cervical vertebrae of mammals are a part of the skull, and it would therefore be wholly incorrect to say that the head of an insect is composed of six segments, if the sixth, or labial segment, remains behind to form the neck region, which is situated back of the head region. It is thus rather surprising to have these entomologists refer to the head of an insect as composed of six segments (including the labial segment) and in the same breath assert that the neck plates behind the head of such an insect are the labial segment. This is assuredly not in conformity with the laws of physics, which assert that a single body cannot occupy two different positions at one and the same time! If the labial segment is in the head region, it simply cannot be in the neck region behind the head region; and when such embryologists as Heymons, Holmgren, Hirschler, Hoffman, Philiptschenko, Strindberg, and every other recent embryologist, with the exception of Riley, are unanimous in asserting that the labial segment is in the head capsule, it would appear that there is some reason for considering that the labial segment is really in the head capsule and not in the neck region behind the head! Heymons and Holmgren have very carefully traced out the portions of the head which are formed by the embryonic labial segment, and I can see no reason for regarding their work as wholly false, especially since it is borne out by the facts of comparative anatomy and is in accordance with the known zoological phenomena. We are thus justified in stating that the only actual embryological proof thus far brought forward, conclusively demonstrates that the labial segment enters into the composition of the head capsule, and consequently the neck plates must be interpreted as intersegmental plates between the real labial segment and the prothoracic segment, homologous with the other intersegmental plates between the other thoracic segments.

Those who maintain that the neck plates are the labial or microthoracic segment, must bring forward some actual proof for their claim. They must prove the falsity of the embryological evidence brought forward by such embryologists as Holmgren, 1909, who have shown that the embryonic segment depicted in Fig. 2 is the labial segment, or they must explain in some other way the presence in the head capsule of an

embryonic segment to which the labium is articulated. They must explain why there are six segments in the head, if the sixth or labial segment remains in the neck region behind the head, to form the cervical sclerites. They must explain the presence in the head region of the labial neuromere. They must explain the lack of segmental structures in the neck region if it is really a "labial or microthoracic segment." They must explain why in the neck region alone in the whole realm of Zoology, a pair of appendages have detached themselves from the supposed segment which originally bore them, and have grafted themselves upon another region; and the description of the hitherto unknown mechanism by which this unique event was brought to pass, will be a distinct contribution to science! Unless they are prepared to admit that the other intersegmental regions (III and V of Fig. 1) were made to appear to be homologous with the neck plates (region I) merely for the purpose of deceiving the unwary, they must grant that these other intersegmental regions between the thoracic segments are also distinct segments, if they claim that the neck region (with which they are in every way homologous) is a distinct segment, either labial or "microthoracic." They must then explain why these new "segments" have no segmental structures, and why embryology offers no indication of their segmental nature. Indeed, the difficulties in the way of accepting the view that the neck plates represent a "labial or microthoracic segment" are so numerous and insuperable, that it is astonishing that any one would deliberately adopt such an utterly unfounded hypothesis and disregard the obvious explanation of the neck plates as an *intersegmental* region between the true labial segment and the prothorax, just like the other intersegmental region between the thoracic segments—a view which, unlike the "labial or microthoracic segment" hypothesis, postulates the occurrence of no hitherto unparalleled phenomenon, involves the operation of no inexplicable mechanism, is in complete accord with all of the observed facts of embryology and anatomy, and is the simplest and most logical explanation thus far advanced to account for the occurrence of the neck plates. On this account we are justified in assuming that the neck plates do not represent a segment either labial or "microthoracic," and it is consequently incorrect to designate them as such.

The term collum is applied to the narrow posterior portion of the head region or to the entire prothorax, by Coleopterologists, and the designation jugulum is applied to the gular region of the head, or to the sides and sternum of the prothorax, so that neither of these terms is available for the true neck region. Since the neck plates are universally designated as the cervical sclerites, the term cervix would be singularly appropriate for the region in question. Dipterologists, however, have very inconsiderately applied the term cervix to the upper portion of the hinder head region in certain flies, and the same term is applied to the posterior constricted neck-like region of the head in other insects, in which the true neck region is also present, so that it would merely create confusion to apply the designation cervix to the true neck region. In order to preserve some form of the term cervix, which is implied in the universally accepted designation cervical sclerites, the neck region was referred to as the veracervix or "cervicum" (Crampton, 1908-1914, Snodgrass, 1910, Martin, 1916) and the former term has been retained in the present paper.

The intersegmental plates between the other thoracic segments are not preserved in many Pterygotan insects. Traces of them occur between the prothorax and mesothorax of *Corydalis cornutus*, between the prothorax and mesothorax of the earwig *Doru luteipennis* (the unknown Forficulid shown in Plate 3, Fig. 19, by Crampton and Hasey, 1915), and in certain Plecoptera and Homoptera. It is in the Apterygotan forms, however, such as *Japyx* and *Eosentomon* (Fig. 1) that the intersegmental plates are best preserved between the thoracic segments, and since these are among the most primitive of living insects, we are justified in assuming that the conditions which they present approximate the original one, in many respects.

In *Japyx* and *Eosentomon* (Fig. 1) the eutrochantin "*t*" intervenes between the coxa and the pleural plate "*pl.*" This condition is preserved in the prothoracic region (i. e. in the non-wing-bearing segment, which is consequently the least modified and the most like the segments of the Apterygotan forms) of many of the most primitive Pterygotan forms such as the Plecoptera, Embiids, certain Forficulids (*Allostethus*) Grylloblattids, Termites, etc., so that I would now consider this condition as representing the original one, and have therefore

designated the plate "*t*" (Fig. 1) as the eutrochantin, or true trochantin, instead of the "pseudotrochantin," which I formerly considered it to be (Crampton and Hasey, 1915). This point, however, will be discussed more at length in a subsequent paper.

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THE ECOLOGY OF BUBONIC PLAGUE.

James Zetek, Ancon, C. Z.

When I entered for the first time the office of the Chief Sanitary Officer of the Isthmian Canal Commission, I saw a large wall chart, the curve of which told exactly how much malaria there was each month on the Canal Zone, expressed as a percentage of the entire working force. This was six years ago. This chart registered the splendid results obtained by the sanitation corps of the I. C. C.; it showed how, although the working force was increased yearly, the malaria rate kept declining yearly. Today malaria is practically exterminated.

This curve showed me more than merely the results of anti-*Anopheles* measures. It showed a definite, seasonal rise and fall in the rate. Malaria was at its lowest from about November or December until April or May, and reached its crest in July. It was the lowest during the dry season, and highest during the wet. Malaria began to shoot upward just after the first heavy rains had fallen. When the dry season approached, the rate fell rapidly. If the dry season was late in coming, then malaria behaved accordingly. The critical factor here is moisture.

The bulk of this malaria is transmitted by *Anopheles albimanus* Wiede., and its racial variety *tarsimaculata* Goeldi. They breed extensively during the wet season. Field inspections show rapid increase in the number of breeding places just as soon as the rains start in. During the dry season it is very difficult to find larvæ of these species. Instead of them, we find plenty of *A. pseudopunctipennis* Theob., a species apparently unimportant in the transmission of malaria on the Isthmus. *Albimanus* is a wet season species; *pseudopunctipennis* is a dry season species. Maximum humidity, maximum malaria and maximum numbers of transmitors of malaria coincide as to time.

In addition to this, it must be noted that the advent of the first heavy rains means also that the workmen get wet, either going to or from their work, or even while working. This means a lowering of their bodily resistance, a factor which is extremely important for the early rise of human malaria.

It appeared to me desirable to learn if such ecological relations could be traced with any of the other diseases directly transmitted by arthropods, especially bubonic plague. World's commerce is becoming so extensive that very soon it will become imperative to open up territories now almost closed to us on account of the presence in them of plague. Quarantine measures are efficacious, but they are also quite expensive because much time is lost. We must fight the plague wherever it occurs. We must get rid of it. This can be done and the cost is relatively low. The study of the ecological relation in plague should reveal to the sanitary officer not merely the kinds of measures he must adopt in order to obtain quick and telling results, but also *when* to employ these measures, and just *where* they must be used in order to obtain maximum efficiency.

I found very valuable data on bubonic plague in the many "Reports on Plague Investigations in India," published in the Journal of Hygiene. During twelve years plague claimed five million victims in India. A trifle over two a minute died during the year 1907! The chart appended to my notes is taken from one of these reports. Other regions where plague is endemic may have a different set of conditions from those in India. These conditions must be well known before the inter-relationships between rat, flea and plague are properly understood and correlated.

A. Plague and Climate.

1. *Bombay City.*—Its climate is hot and dry, the daily mean temperature being from 70° to 80° F. The average diurnal range in only 12.5° F. The S.W. monsoons appear from May to October, and they bring the rains. These rains are heaviest from June to August. The N-E monsoons, which blow from November till April, bring very little or no rain.

The plague epidemic begins in January, rises gradually until it reaches its maximum in March, then declines to a "normal" about the middle of May. Charts which were kept for ten consecutive years show *plague mortality lowest when humidity was highest*, (June to September), and that an almost automatic recession from the maximum takes place as soon as the humidity begins to rise. The mean temperature at the beginning of the rise is from 72° to 75° F., but as soon as it

reaches 78°-80° F., mortality drops off. Slight recrudescence may occur during May to October, i. e., when a fall in the mean temperature occurs. It should be borne in mind, however, that the single factor temperature is not the critical one; it is rather the resultant humidity which counts.

2. *Poona City and Cantonments.*—It is 80 miles from Bombay, 2,000 ft. above sea level, and has a daily mean temperature of from 70° to 80° F., with an average diurnal range of 22.5° F. From May to October it is subjected to the S-W monsoons, but the rainfall (March to June) is less than that of Bombay. June is the hottest and dryest month, its daily mean temperature being from 83° to 90° F. In July the daily mean is from 75° to 80° F., with S-W breezes. The winter months have a daily mean of about 70° F., and an average diurnal range of about 30° F.

The plague epidemics occur between August and March. The charts show that *mortality increases rapidly as the humidity recedes from its maximum crest.* The period of high plague mortality is relatively short, dropping off as soon as the humidity rises.

3. *Nagpur City.*—It is in the Central Province and resembles much Poona, excepting that its mean temperature is slightly higher. Its hot season is from March to June, the mean temperature being from 85° to 95° F. During July to September the temperature is a little over 80° F., while during the cold months (November to February) it is from 70° to 75° F. The rainfall occurs from June to September, and ranges from 40 to 60 inches.

Plague epidemics were most favorable from November to March, and the charts again show *plague mortality lowest when humidity was highest.*

4. *Belgaun City.*—This is in the extreme south of Bombay Province, 2,500 ft. above sea level, and 75 miles inland from the West coast of India. The mean temperature from June to February is from 70° to 75° F., with an average diurnal range of 20° F. March to May is the hot period, the daily mean being about 80° F. The rains occur mostly from June to October, and amount to about 40 inches.

Epidemics begin in July or August and reach their maximum in October. The charts show *plague rising rapidly as soon as the humidity retreats from its maximum.*

5. *Lahore City.*—It is 700 ft. above sea level. It is not within the hot mansoon belt. The rainfall is slight, amounting to about 20-25 inches, and occurs chiefly from July to September. Some rain falls at times during January and February. From November till March the daily mean temperature is below 70° F., in January as low as 54° F. The remainder of the year is above 70° F., from May to August as high as 85° F. to 95° F. The average diurnal range is 27.5° F. (April to May it is 32.5°, and October to November it is 35°.)

Plague epidemics occur from March to May. There is a tendency to recrudescence during the winter months. *Plague mortality rises rapidly as the humidity recedes, but as soon as the humidity begins to rise, the epidemic is quickly terminated.*

6. *Rawalpindi City and Cantonments.*—Situated at the base of the Himalayas, 1,700 ft. above sea level, it has an average diurnal range of from 20° to 30° F. Its hot weather comes from May to August, with a mean temperature of from 80° to 92° F. The rainfall, mostly from July to September, amounts to but 30 or 40 inches. About eight inches of rain falls during the winter season, January to April.

The plague epidemic is from September to November, with slight recrudescence practically throughout the year. *The major epidemics rise rapidly as the humidity recedes.*

7. *Summary:* The authors of the several articles from which these notes were taken, draw certain conclusions, which in brief are: That a temperature of 85° to 90° F., or one of 50° or less, are very unfavorable to plague. This holds true for Bombay City, but does not for Poona and other cities. The truth of the matter is that no one factor alone may exert such wide influences, but that it is rather a resultant of several factors—in this case it is *humidity.* When plague mortality and humidity are placed on the same chart, it becomes at once evident that there is a direct relation between the two.

We shall see a little later on, that *the severity of an epidemic of bubonic plague bears a direct ratio to* (*a*) *flea prevalence and* (*b*) *to humidity.*

B. Fleas.

The investigators in India report that a temperature above 80° F. affected the conditions to which the bacillus was subjected in the flea's stomach. At high temperatures the bacillus

disappears from the stomach more quickly than at lower temperatures, i. e., 70° to 80° F. They found fleas remained infective for longer periods at lower temperatures. A temperature of 50° or less, may directly influence plague prevalence. Fewer rats were found with developed septicaemia at low temperatures than at higher ones.

From an explanatory standpoint these facts mean that due to heat, frequent evacuations take place in the flea, and as a result of this, the bacillus in the digestive tract of the flea is filtered out with greater frequency.

Another excellent observation was that high temperatures retarded both egg deposition and development, and that low temperatures prolonged the life cycle. This should be humidity because high temperatures in India were associated always with high humidity. Humidity, then, is inimical to the flea. The chart shows fleas at their greatest abundance from February to May, their numbers dropping off rather sharply after May, and the cause of this is the humidity which is on the increase from June to August.

Nearly all reports on plague show that its maximum coincides with the period of maximum numbers of fleas. Kitasato (1909) finds that the absolute and relative abundance of *X. cheopis* is much increased during the autumn, i. e., during the plague season. Tidswell (1910) gives a table of the flea population per month per one thousand rats, the average mean monthly temperature, and the average mean monthly humidity; the flea abundance corresponds with the plague season.

The chart for Bombay shows the fleas on *M. decumanus* increase in numbers from June to August, outnumbering those on the black rat. This period is one of heavy rains, and these drive the brown rat from its subterranean burrows, cellars, etc., and force them into dwellings, i. e., into drier situations. Rat breeding increased at this time, due to the ravages of plague among them during the previous months. This influx of rats into a drier habitat is most favorable to the rapid development of fleas.

Quite naturally, the houses in the barrios which are near wharves, etc., may show slight recrudescences of plague at a time when plague in general had declined.

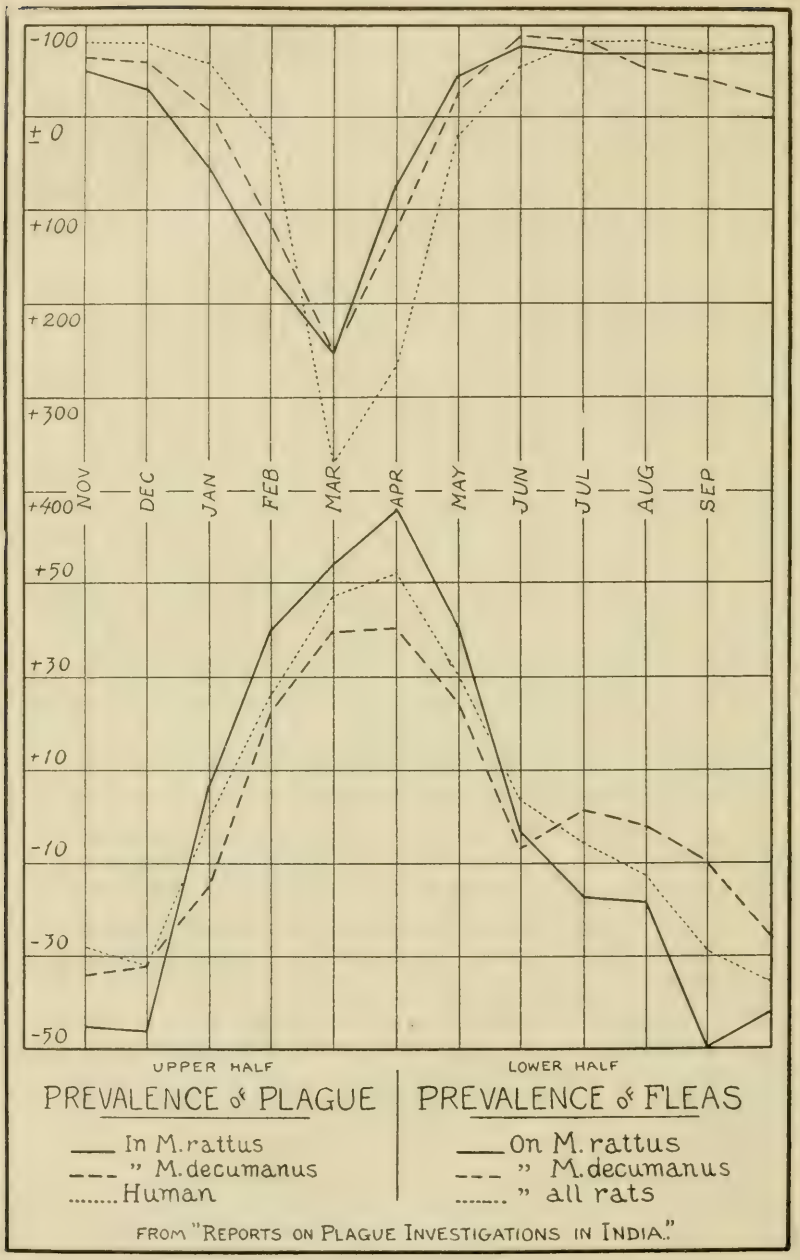
C. Rats.

During November to February, the winter season at Punjab, rat breeding was at its lowest; this is a pre-epizootic period. During the rest of the year the portion of pregnant females to non-pregnant ones was always at or above the mean. Breeding was most vigorous during April, September and October. The plague season was from February to June. At Bombay, the brown rat, *M. decumanus*, breeds the year round, least from December to February, a pre-epizootic period. During March, July, August and October, breeding was most vigorous. The plague epizootic among the rats begins in January, rages during February and March and rapidly declines in April. The same held true with the black rat, *M. rattus*.

The effects of plague are very evident at first among the large numbers of the rats that die; this means there is a superabundance of rats non-immune to plague. But later on in the stage, there appear quite a number of immune rats, and these furnish the start for the next increase, plenty of young, susceptible rats for the next plague rise. The influence of plague in the rat association is in the nature of a radical disturbance of equilibrium. The reports show very nicely how, after a large percentage of the rats had succumbed to plague, there came a vigorous breeding spell. This sudden breeding-fit is but a natural effort to re-establish again a relative equilibrium. The habitat remained favorable throughout.

Jennings (1910) found 2.20 fleas per each norway rat (*Mus norvegicus*) he examined, and 3.61 fleas per each black rat (*M. rattus*). The difference is not due to the texture of the fur in the two species, but rather to the nesting habits of the two species. The norway rat is more ferocious and its burrowing habit is more pronounced. It constructs its tunnels anywhere it can, mostly where it is moist. The black rat, on the other hand, builds its nests above the ground, in the walls of buildings, etc., consequently in a drier habitat. Moisture is inimical to the flea larva and adult, and therefore the greater number of fleas on the black rat.

Heavy rains affect rats and fleas. They drive them from the wet or submerged burrows into drier situations, and this means closer contact with people as well as increased flea breeding.


-100
± 0
+100
+200
+300
+400
+50
+30
+10
-10
-30
-50
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
UPPER HALF
LOWER HALF
PREVALENCE of PLAGUE
In M. rattus
" M. decumanus
Human
PREVALENCE of FLEAS
On M. rattus
" M. decumanus
" all rats
FROM "REPORTS ON PLAGUE INVESTIGATIONS IN INDIA."

Gauthier and Raybaud (1903) find that the Indian Plague flea, *X. cheopis*, constituted 25% of the flea population upon ship rats at Marseilles, and that the numbers rapidly became fewer as the distance of a locality from the docks increases. Jennings (1910) found that 97.9% of the fleas on rats examined by him at Panama were the Indian plague flea. We have no plague endemic in the Canal Zone (thanks to efficient quarantine), but we have everything favorable to plague epidemics—the right fleas, plenty of rats, and a wet and dry season.

D. The Plague Association.

The severity of an epidemic of bubonic plague was shown to depend upon flea abundance and upon humidity. Fleas are abundant if rats are abundant, and humidity is the critical factor determining at what time of the year fleas are most abundant. The reports of the plague commission show that at Bombay City rat breeding was at its minimum when humidity was lowest, and vice versa, it was most vigorous when humidity was highest. Plague was highest when humidity was lowest, and large numbers of rats were killed off, leaving only a few immune ones with which to start the next progeny. As plague dropped off, and to readjust the loss of equilibrium in the rat world, there followed a vigorous breeding spell. This is with humidity high. A new colony of non-immune rats resulted. The rat epizootic began in January and declined in April. During this period fleas reached their maximum.

Referring to the chart for a moment: Fleas on all rats were at a maximum in March and April. Plague mortality in rats reached its culmination in March. The fleas which left their dead hosts increased plague among human beings from about plus 20 to plus 360 *within one month!* From May on, plague recedes; this is the period of the S-W monsoons, the rain winds.

The chart shows more fleas on the black rat, *M. rattus*, than on the brown rat. This was found true on the Canal Zone by Jennings. It places the black rat into greater importance with respect to the transmission of human plague. This rat is the common Canal Zone rat; so is *X. cheopis* the common flea, whose natural host is the black rat.

These notes show that *the severity of an epidemic of bubonic plague bears a direct ratio to* (*a*) *flea abundance and to* (*b*) *humidity*. This holds true for India. No doubt it holds true for other places where bubonic plague is endemic. The same set of conditions may not be duplicated elsewhere, but the ecological relations will in the main part correspond to those of India.

I am indebted to Dr. S. T. Darling, formerly Chief of the Board of Health Laboratory of Ancon Hospital, for the use of his library.

1903. **Gauthier & Raybaud.** Revue d' Hygiene, XXV, p. 426.
1908. **Indian Plague Commission.** Journ. of Hygiene, Vol. VIII and IX.
1909. **Kitasato.** Trans. Bombay Med. Congress, p. 93.
1910. **Tidswell.** Rpt. of the Gov. Bur. of Microbiology for 1909 (Sydney) p. 20.

1910. **Jennings.** Rats and Fleas in Relation to Bubonic Plague, with Special Reference to Panama and the Canal Zone. Mt. Hope, C. Z.

THE INTRODUCTION OF SCOLIA MANILAE ASHM. INTO THE HAWAIIAN ISLANDS.

By F. Muir, Hawaiian Sugar Planters' Association.

In July, 1912, the presence of *Anomala orientalis* (Waterhouse) was first recognized in the Hawaiian Islands, where it was found injuring the roots of sugar-cane. There are reasons to believe that it was introduced into the archipelago, probably in the soil of potted plants from Japan, more than four years before its presence was discovered. Although in 1912 it was confined to a comparatively small area, yet it was too widely spread to hope to exterminate it by drastic measures. As the use of insecticides did not prove any more successful here than elsewhere, it was decided to try and introduce insect enemies known to attack Scarabaeidæ in other parts of the world.

In judging of the probable utility of such enemies, it must be borne in mind that the biological environments of the Hawaiian Islands are very unique. Although the native insect fauna is rich in species of several groups, there are several large groups totally unrepresented. The whole of the great complex of the Lamellicornia is only represented by a single genus of Lucanidæ (*Apterocychus*) with a few allied species confined to Kauai, the most isolated and north westerly Island of the group. Of the enormous family of Scarabaeidæ not a single species is native, and there are good reasons to believe that the few species that are present have been introduced since the advent of the white man. *Adoretus tenuimaculatus* Waterhouse (known locally as the Japanese or rose beetle) was introduced from the Orient about 1896 and is one of the worst garden pests in the Islands, making the growing of roses in the lower and dryer districts very difficult, and spoiling the looks of many of the ornamental shrubs, on account of the ravages of the adult insect. The natural corollary of these conditions is the total absence of all the natural specific enemies of the Scarabaeidæ, such as *Scolia*, *Tiphia*, *Presena*, etc., which play an important part in keeping these beetles in check in other parts of the world; also the absence of those Mutilids, Bombyliids, Rhipiphorids, etc., which are known to attack the above parasites. It is this simplicity of biological environments

that has, above everything else, made the controlling of certain insect pests by introduced insect parasites the success that it is.

Early in 1913 one of the members of the H. S. P. A. Experiment Station proceeded to Japan and eventually to Formosa, Java and the Philippines, to study the death factors of *Anomala*, *Adoretus* and allied "white grubs." The work is still in progress but as this is the first record of the successful introduction and establishment of a *Scolia* in a new region a brief statement of the establishment of *Scolia manilæ* Ashm. in Hawaii may be of interest to others working on similar problems.

This insect was described by Ashmead from specimens collected by Father Brown in the Observatory Gardens in Manila. It is very common in the grounds of the College of Agriculture at Los Banos, some forty miles from Manila, and it was here that most of our work was done. The Dean of the College very kindly placed the college insectary at our disposal and assisted us in every possible way.

After experimenting with different methods of handling the parasite we eventually adopted the following methods: A small quantity of soil was placed in the bottom of a small jelly jar with a tin cover, two *Anomala* or *Adoretus* grubs were placed in the soil, a twig of *Alternanthera versicolor* sprinkled with water and a few drops of honey was stuck in the soil and a female *Scolia*, caught in the field, was placed in the jar. After twenty-four hours the jars were turned out and each grub which bore an egg was placed in an artificial mud cell and the entrance closed with mud; the cells were packed in moist soil in tins with tight-fitting lids, and the tins in wicker baskets or boxes were shipped from Manila to Honolulu. By the time that they reached Honolulu the Scolias had pupated, and the cocoons were then placed in damp moss and the adults, when hatched, mated in captivity; a certain proportion were turned out in the field and a proportion retained for breeding. The mating was easily accomplished by confining a female in a sleeve-cage with a number of males and placing the cage in the sun. When shipping by direct or fast boats no Scolia hatched out during the voyage, but by more circuitous routes or by slow boats, a larger or smaller percentage would hatch out and die. On an average, sixty per cent. of the eggs placed in cells went through

to pupæ. For a time we tried placing the cocoons in glass tubes packed in moss, but this method of shipment was not so successful.

The length of the life cycle varied considerably. In Los Banos the average was about 40 days, shortening by a week or ten days under favorable conditions in the summer and lengthening to two months or more in the dry winter months. A similar variation takes place in Honolulu, some specimens having been three months in the cocoon. Small differences of temperature and moisture appear to effect them, especially in the resting larval or early pupal stages.

On one occasion a consignment of adult *Scolias* and *Tiphias* was brought over in a cage with growing *Alternanthera*, but this method could only be used successfully when the cage was accompanied by some qualified person, as the insects require proper attention as to moisture and food.

Between December, 1915 and January, 1917, 6,578 eggs, pupæ and adult Scolias were shipped from Manila and 1191 living females and 973 living males arrived or hatched in Honolulu. Of 1691 cocoons shipped in glass tubes or moss 101 females and 54 males hatched in Honolulu; of 3884 eggs sent in mud cells, 1057 females and 908 males hatched out in Honolulu. These figures do not include those that issued during the voyage and died.

On March 13, 1916, one hundred and fifty cocoons received from Manila were buried in a field where *Anomala* larvæ were abundant. Subsequently those were dug up and it was found that thirteen adults had issued. August 2, 1916, one female and six males and on September 9 sixteen females and twenty-two males were liberated in the same locality. On September 16, the insects were found flying about in numbers that clearly indicated that they had become well established and were increasing rapidly. In January, 1917, they were so numerous in this locality that it was possible to catch as many as 175 females in one morning, and as many as 1606 females were caught during seventeen visits of a couple of hours each, and no diminution was observed, as more were caught on the last day than on the first. These were used to colonize other localities. If males had also been taken, six or seven times this number could have been caught. In other localities where colonies were liberated the Scolia is now known to be established.

It will not be possible to estimate the ultimate effect of this parasite upon the *Anomala* problem before the end of the present year, but the prospects are good. As *Scolia manilæ* attacks *Adoretus* as well as *Anomala*, we hope that it will be beneficial in our gardens as well as in our cane fields.

During the course of this work we have experimented with several species of *Tiphias*, two species of *Prosena*, a *Dexia*, and a *Campylotheca*, also with several predators. Up to the present we have not succeeded in establishing any of these in Hawaii. In Japan there is a species of Asilid fly which is very active in the larval stage, attacking the larvæ of *Anomala*, and in the adult stage attacking the adult beetle, but we have had to eliminate this from our work as it is also very active against bees.

Bacteria acting upon the grubs have been found in all the countries in which we have carried on our work and it plays an important part in keeping a check upon Lamellicorn grubs. In Hawaii it has been noticed, and I have similar experience elsewhere, that a field badly infected with Anomala grubs will recover and be comparatively free for a period, and the writer has reasons to suspect that in some cases this is due to the accumulated bacteria in the soil making it too unhealthy for the grubs.

Fungus is also very effective in wet districts, and in dry districts during the wetter season.

Efforts were made to find an egg parasite and many thousand of eggs were placed in various situations, but without results. Ants and terminates attacked the eggs as well as the usual coleopterous predators.

After three years study of the death factors acting upon these beetles in Japan, Formosa, Java and the Philippine Islands the writer concludes that the problem is a complex one. The death rate is far highest among the eggs and larvæ and natural selection has been a small percentage to act upon in the adult stage, and the specific characters of these beetles show little or no effect of natural selection.

SOME RECENT ADVANCES IN MOSQUITO WORK.

THOMAS J. HEADLEE, Ph. D.,
Entomologist of the N. J. Agric. Experiment Stations.

CHARLES S. BECKWITH, B. Sc.,
Assistant Entomologist of the N. J. State Experiment Station.

At the outset the writers wish to state the present status of mosquito work in New Jersey. Approximately 95,000 acres of the salt marsh has been rendered reasonably free from mosquito breeding. This has involved the cutting of about 11½ million feet of ditches 10 inches wide and thirty inches deep or their equivalent, the building of 17.2 miles of dike, the installation of 76 sluices and tide gates (representing 842 sq. ft. of cross section outlet opening), the installation of one four and one twelve inch centrifugal pump and the connection of 100 acres of marsh with a large sewage pumping plant. Approximately 50 per cent of the reasonably permanent fresh water mosquito breeding pools scattered over 315,000 acres of upland has been permanently eliminated.

During the past year 3,289,120 linear feet of narrow 10 x 30 inch trenching or its equivalent has been installed in the salt marsh, 8,200 lineal feet of dike have been built, and 30 sluices and tide gates have been constructed and placed, affording 371 sq. ft. of cross section outlet. Approximately 95,000 acres of salt marsh have been patrolled throughout the mosquito season and the mosquito breeding thereon, which drainage systems did not prevent, destroyed in so far as possible. Approximately 315,000 acres of upland have been likewise patrolled, a large amount of draining and filling completed, and as nearly as possible all residual breeding destroyed. As a direct result a very considerable measure of protection has been given to 1¾ millions of people. The cost of the whole operation has been less than $210,000, or about 12 cents per capita.

Although a certain amount of drainage is yet to be done within the areas already covered, the great centers of population, which were formerly over run with mosquitoes, are now pretty well protected; and the present outlook is that the protection will grow better from year to year through the substitution of permanent for temporary elimination.

The great problem yet remaining is to free the sea shore and rural communities of southern New Jersey from the mosquito incubus by draining the remaining acreage of salt marsh.

Until 1912 the sole official agencies at work were the boards of health and the New Jersey State Agricultural Experiment Station, and for various reasons little was accomplished by the former. Since that year the County Mosquito Extermination Commissions and the New Jersey Experiment Station have worked on the problem in close co-operation.

In 1916, under the able and effective leadership of Dr. Haven Emerson, Commissioner of Public Health of the City of Greater New York, all salt marshes lying within its borders (except those on Staten Island, which were drained some years ago), have been drained or are now in the process of being drained. Under the authority of an act of 1916 a mosquito commission was organized in Nassau County, which lies in Long Island just east of the Brooklyn and Queens Division of Greater New York, and the work of draining the salt marshes, which had already been begun on the south side by private subscription, was undertaken in a systematic manner. The amount of work involved in Greater New York and Nassau County is shown by the fact that more than 5,000,000 lineal feet of narrow trenching or its equivalent have been cut or contracted for cutting. In addition to this, a certain amount of upland control work has been done, but with its exact nature and extent the writers are not familiar.

For the purpose of unifying the mosquito control work of the three states concerned, an Inter-State Anti-Mosquito Committee was formed under the leadership of Dr. Emerson. The committee consists of representatives of Connecticut, New York and New Jersey.

Having laid this basis the writers will now turn attention to some of the striking changes that have been made in response to the practical needs of mosquito control work.

CHANGES IN SALT MARSH DRAINAGE.

In 1904 at the close of the preliminary investigations of the problem it was thought to be necessary to drain only the marsh where breeding was found in such a way as to cause the water to flow in and out with the tide and to afford the killifish ingress at all times to all parts of the salt marsh known to breed. In

fact, this continued to be the thought until 1913, when it became clear to the senior author and others that there were at least two fundamental weaknesses in the working out of this plan. The first was the assumption that the salt marsh has certain breeding areas which may be determined in the course of one or two inspections and which if drained will free the marsh from breeding. The second was the assumption that all salt marshes respond to drainage systems of the above sort.

In 1913 the senior author was led to suspect and in 1914 to prove that certain areas in the salt marshes of the upper Hackensack Valley, which had been reported as in non-breeding territory, were really at times very prolific producers of salt marsh mosquitoes. This experience has since been repeated so frequently at different points of the supposedly drained salt marsh that the writers are convinced that every undrained area of grass, cattail or reed covered salt marsh is potentially dangerous unless it is swept with great frequency by the tide; and that even such tide swept areas may, in certain seasons be covered at such infrequent intervals as to permit breeding.

In 1914 the drainage systems established in Essex and Union Counties on the original plan utterly failed to prevent the issue of an enormous brood of salt marsh mosquitoes between July 15th and 20th. The failure was directly traceable to an unusual combination of long continued, extremely high tide with a period of much rain and cloudy weather. Other parts of the coast served with the same system of ditching, in many instances in a less completed state, were adequately protected. The difference seemed to lie in the fact that the east wind banked the waters up in land-locked Newark Bay and created a condition which did not obtain along the more open parts of the coast.

Although this failure was chargeable to an unusual condition of tide and weather, it was made possible by peculiar geographical location and might any year be repeated. It was, therefore, sufficient to condemn the system and to indicate that some radical change must be made.

After carefully considering the matter it was decided that the most feasible plan was to keep the sea off the marshes by dikes, to outlet the water through sluices and tide gates, and thus create a reservoir capable of absorbing heavy rainfall

without covering the surface and initiating mosquito breeding over large areas.

Accordingly, since 1913 new drainage has been planned to open not merely the places in which breeding has been found but all parts of the marsh, which are not swept at frequent intervals by the tide. Furthermore, since 1914 the areas on which the narrow trenching with its outlets failed to afford protection, have been placed under dike, sluice and tide gates as rapidly as possible.

Some salt marsh areas in the Hackensack Valley lie so low that their drainage by gravity flow is impracticable and they have in some instances become so charged with sewage as to breed the house mosquitoes as well as the salt marsh forms. In such places low head centrifugal pumps are being installed as rapidly as possible. A twelve inch pump of this type seems to be able to protect from 800 to 1,000 acres of land.

In the course of this diking, sluicing, and pumping work the problem of taking care of the sewage has presented itself. As a rule the open sewage streams have been arranged to open into tidal creeks, with a result that the ditches and creeks have soon become choked up and the raw sewage spread over large areas of the marsh. The plan adopted has been one of diking the borders of these sewage charged ditches and creeks, thereby causing the sewage to be carried out to sea by gravity, and to outlet the waters of the marsh either through sluices or by pumps into the sewage charged streams or other available outlets. Inasmuch as the city and borough engineers have usually planned to outlet their sewers into the best tidal streams of the areas in question it has been necessary as well as to deliver the marsh water through them.

ADVANCES IN KNOWLEDGE OF MOSQUITO DISTRIBUTION.

The method of determining the flight of salt marsh mosquitoes formerly practiced consisted in securing of reports from cooperating observers relative to the time when the mosquitoes arrive, and in efforts to follow their flights along trolley and railroad lines. With the advent of the automobile as a common means of transportation tracing the flight of salt marsh mosquitoes became a simple matter. In a day's time a freshly emerged brood could be traced to its source, and the basis promptly laid for the prevention of further

trouble from that area. This method of tracing broods of salt marsh mosquitoes was first tried in 1913 and the results were so satisfactory that it has been used constantly since that time.

In making a study of this sort, the usual plan is to drive to a point where the brood has been reported. From this point, collections are made outward along lines running to the north, west, south and east until no further specimens can be taken, or until the marsh from which the mosquitoes came has been reached. This will, without doubt reveal the direction of the source of the brood, unless the mosquitoes have been out long enough to lose their connection with the marsh from which they came. When the marsh from which the brood came, has been reached, some idea of the part from which it came can be had by running a collection line along the edges and discovering the point where the mosquitoes are most abundant. In most cases the place of breeding will be found nearest this point, but in others this process will offer little clue, for a heavy growth of trees may attract sufficient numbers to give a false impression or the direction of the wind may have produced concentration at a distant point. Nevertheless the determination of density gives a point of departure and is worth while when dealing with the problem of finding the pupal skins on a large area of salt marsh.

In running these collection lines the purpose is to determine the density of the mosquito fauna. It is, therefore, necessary to organize each collection on some sort of a unit basis, and in order to eliminate the serious interference of local conditions to make all collections in as nearly similar situations, especially as relates to cover, as possible. The whole series of collections is usually made within the limits of a single day. Starting in the morning about 8:00 A. M., collections along the first line are made. At each point the collector gets out of the machine, enters the type of growth selected and using two cyanide tubes catches as many specimens as possible in a limited period—say 15 minutes. He then reckons his catch in terms of so many specimens of the species concerned per minute. The distance between stations depends upon the area to be covered. When dealing with a small area the intervals are short, say, anywhere from ¼ to 1 mile, but when dealing with an issue that covers a large area the distances range from 2 to 5 miles.

In 1913 the success in tracing the salt marsh species lead to an attempt to trace the house mosquito which exhibited marked concentration in certain areas within which and in the vicinity of which no serious breeding of the species could be found. Daylight collections promptly proved inadequate because the house species would not readily attack the collector. Resort was then had to evening collections, but the variations in time required for one collector to cover the whole area seemed to introduce a variable fatal to the result. To meet this difficulty a number of collectors were employed along two lines of collection running through the mosquito zone at right angles to each other. Enough men were employed that the entire collection could be secured within the limits of 1½ hours. By this means the collections were found to bear an understandable relation to each other, and by following the directions of increasing density the source of breeding has been found. In this way a zone of house mosquitoes originating in a sewage charged salt marsh has been found which extended a distance of 2½ miles from the place of origin.

The fact that nearly all species were taken in these evening collections led the senior author to wonder whether the process might not be used to determine the density of the mosquito fauna throughout the protected area and thereby check up the efficiency of the control work and point out the places where greater effort was needed.

In 1914 he had an opportunity to try out the matter in Passaic County with the efficient assistance of Mr. David Young. He found that not only did the method seem to show up the efficiency of the control work, but served to demonstrate the inefficiencies in time to permit their correction before the householder was seriously troubled. The study seemed to show that there existed a mosquito fauna of such an attenuated character that the householder did not realize its existence and that variation in it could be determined in time to head off a really dangerous increase in number.

In 1915 the evening collection became a part of the regular mosquito control work in Essex, Passaic and Union Counties and in 1916 it was employed in Bergen, Essex, Passaic, and Union and utilized to some extent in Hudson, Middlesex, Monmouth, and Atlantic Counties. It has enabled these counties to detect promptly invasions from extra-territorial limits as well as incipi-

ent outbreaks within their boundaries. In 1916 it served to demonstrate that the dominant species in Bergen, Essex, Middlesex, Passaic and Union was the fresh-water swamp mosquito (*Aedes sylvestris* Theob.) and to show that the next problem consisted in the elimination of the breeding places of that species.

In 1914 Mr. Harold I. Eaton, Chief Inspector of the Atlantic County Commission, undertook the determination of the important factors governing the flight of the white marked salt marsh species (*A. sollicitans Wlk.*), for the purpose of determining where the limited amount of money available for the use of his commission could be spent with the prospect of affording the people of the county the largest measure of protection. Atlantic County has 50,000 acres of salt marsh and beyond its borders both to the north and the south lie many thousands of acres of undrained marsh. He found that this species took flight on winds of low velocity (10 miles an hour or less), high relative humidity, and high temperature. Under other conditions than these, migration proceeds with extreme slowness and covers only short distances. The studies of the writers before and after Mr. Eaton's tests simply serve to confirm and extend the results as stated.

In 1916, Dr. F. E. Chidester, working at the time under the senior author's direction, determined that, during the mosquito season, the principal factor in the time and geographical distribution of the brown salt marsh mosquito (*Aedes contator* Coq.) and the white marked salt marsh mosquito (*Aedes sollicitans* Wlk.) is the degree of salinity of the water to which they are subjected. He found sea-water of salinity 6 to 8 per cent. to be favorable to the former and injurious to the latter, while a salinity of 10 to 15 per cent. was favorable to the latter and injurious to the former.

This discovery fitted well the observed distribution of the two species and seemed to offer an adequate explanation. Be that as it may, the brown salt marsh species is dominant in the spring and early summer throughout the area at a time when the water has been greatly diluted by melting snow and spring rains, and remains so throughout the season along the upper courses of the rivers where the salinity never rises much above the favorable per cent. The white marked salt marsh

species is dominant from early mid-summer on or during the period when the salinity rises to the degree favorable to it.

In the beginning of a study of this sort the student may be confused by his findings, for he may discover the larvæ of both species in the same pool with salinity either high or low. He will soon find, however, that larvæ under these conditions are all well grown or that the extremely small larvæ are of the species favored by the salinity. This mix-up of large larvæ of the two species is due when the salinity is extreme in either direction, in the writers opinion, to larval distribution by high tides.

SOME UNSOLVED PROBLEMS.

Many problems of mosquito work which are important from the standpoint of the practical work of control are yet without solution.

Ditching systems on the salt marsh are rapidly multiplying and some machinery especially adapted to the work of cleaning and repairing them should be devised.

Until the late summer of 1915 and the season of 1916 the fresh water swamp mosquito had formed, except in the vicinity of great swamps, a minor portion of the problem of control. The fact that since that time it has been the dominant form over a large part of the protected area indicates clearly that a further study of its life economy must be undertaken.

Collections of mosquitoes on the wings have failed to reveal the flight habits of *Anopheles quadrimaculatus Say*. It is rarely taken in collections except very near its place of breeding.

The oils used for larvicides need to be standardized and a really practicable larvicide soluble or at least miscible with water should be found.

A practicable way to reduce the mosquito fauna, which survives the faithful practice of the present methods, should be discovered, for the failure of the mosquito fighting machine in any particular way, during trying weather, all too promptly increases the ever present minimum to a troublesome number.

NEW SPECIES OF COLORADO SYRPHIDÆ.

CHARLES R. JONES.

Microdon similis n. sp.

Length 14 mm. Head black, clothed with yellowish pile, front wide, sides nearly parallel throughout, a narrow, shining oblique transverse groove running from the base of the antennæ to the eyes; antennæ dark fuscus, the first joint linear, equal or sub-equal in length to the second and third together, arista black, tip slightly reddish. Thorax of a bronze black, clothed with yellow pile. Scutellum rounded, black, with the apex slightly emarginate, but plain, pile of the same color as the thorax, slightly longer and more abundant. Abdomen black, short, slightly shining, less than twice as long as wide, finely punctulate; dorsum with stout black pile, the lateral margins with yellowish pilose, pile of the first segment long, whitish, and forms a distinct uninterrupted transverse cross-band on the posterior portion of the segment. Legs black, pile of the tibia whitish, hind metatarsi slightly diolated and not quite as long as the remaining joints together, clothed with short, stout, reddish pile. Wings sub-hyaline, the veins narrowly blackish.

Two specimens, Poudre Canon, Colorado., C. S. Mead, Coll.

M. similis differs from *M. tristis* in that the thorax of the latter is obsolete cupreous lineate and the former is not; that the antennæ of *tristis* is testaceous at the base while the antennæ of *similis* is entirely black; that the length of *tristis* is from 7 to 10 mm., while *similis* is 14 mm.; and in that the emarginated scutellum of *tristis* is armed with a sharp, tooth-like projection on each side and *similis* is only slightly emarginate and plain.

Melanostoma cherokeenensis n. sp.

Length, ♂, 7 mm., ♀, 7.5 mm. General color black, body linear, face bluish, yellow reflecting, white pollinose, pile black and white, tubercle rounded, not very prominent, shining black. Front of female slightly depressed, with whitish pollinose and black pile; vertex shining black, black pile, cheeks bluish black, white pollen and black pile near the eye, white pile along border. Occiput broad, whitish pollen and pile. Antennæ brownish black, third joint rounded. Thorax shining metallic green, with black and white pile. Pleura with white pollen and pile. Scutellum yellowish, lightly dusted with light pollen, which gives it a bluish reflection, dorsum with long black, sparse pile, bordered with whitish pile. Abdomen velvety, bluish-black with short, white pile and three interrupted yellow cross-bands, all separated from the lateral margin. In the female, the spots of the second segment are orange, quadrate, and near the middle of the segment; the lateral portion lightly dusted with white pollen; spots of the third and fourth segments

similar to the first, but nearer the anterior margin of the segment, and considerably larger; segments four and five with a narrow, yellow, posterior border. Legs black, with white pile, knees fuscous, hind metatarsi only slightly or not at all thickened, tarsi with short, stiff, yellow pile. Wings hyaline, stigma yellow. Male differs from female in having the face with more of a bluish tinge; the cheeks are black and the oral margin has a yellow spot on it. The scutellum is darker and the pile is about twice the length of that of the female; the first abdominal spots are triangular and very small, and the fifth segment has no yellow posterior margin.

Two males, one female. C. S. Mead, collector, Cherokee Park, 7600 ft., July 30, 1913.

Melanostoma johnsoni n. sp.

♀, 8 mm. Thorax blue or greenish metallic, head shining, bluish or green. Face prominent with whitish pile and lightly dusted on the sides with whitish pollen, tubercle and middle shining, a narrow transverse pollinose stripe below the antennæ which projects upward in the middle between the antennæ, front shining, lightly dusted on side with whitish pollen, a shining spot immediately above and surrounding the antennæ, pile black. Vertex shining, black pile. Antennæ elongate, third joint as long as the two preceding joints, sub-quadrate viewed from above, brownish, light-reddish underneath, arista brown, basal; occiput whitish pollinose, with whitish pile. Thorax metallic dark blue, or green, shining, with whitish pile. Scutellum of the same color as the thorax with marginal pile longer than the rest. Abdomen ovate, shining, brownish, with short white pile, which is longer on margin and near the base, and three pairs of yellowish abdominal spots. Second segment with two small oblique medial yellowish spots, segment three with two similar spots, but larger and more ovate. Spots on segment four similar in shape and size to the front pair. Legs testaceous, hind femora, except at the base and the tip, part of the tibiæ and the tarsus, fuscous, hind metatarsi slightly thickened. Wings hyaline, stigma yellow.

Habitat: Two females. S. A. Johnson, collector, Denver, Colorado, April 4, 1902.

Melanostoma monticola n. sp.

Length, ♀, 7 to 9 mm. Face projecting, slightly excavated below the antennæ, whitish pollinose, with white pile, shining black; epistoma projecting downward, tubercle prominent, a smaller one on oral margin; from tubercle up to the base of the antennæ a slight median depression; above the insertion of antennæ two slightly raised, black, arcuate ridges, meeting on the median line. Front shining metallic green, whitish pollinose on sides, black pilose, and slightly depressed; vertex shining metallic green, black pile; eyes converging at apex. Cheeks black, white pilose. Antennæ brownish, third joint reddish below, sub-ovate; arista bare. Thorax shining metallic green, white pile. Scutellum of the same color, pile short, a slight depression following

contour of scutellum making a narrow border on its entire posterior portion; pleuræ whitish pollinose, with white pile, abdomen shining black, narrowly ovate, pointed at tip; first segment sub-opaque, white pollinose, with white pile, second segment on the sides with a semi-quadrate yellow spot; third and fourth segments with larger yellow quadrate spots which touch the anterior margin of the segment, fifth segment with a pair of small triangular spots. The abdominal spots are lightly dusted with whitish pollen. Legs fuscous or brown, white pilose, hind metatarsi not thickened, hind femora black, or having base yellowish; coxæ black; wings hyaline; stigma yellowish.

Habitat: Six females, Cherokee Park, Estes Park and Carbondale, Colorado. C. S. Mead and J. C. Bradley, collectors. July 12, 1908; July, 1913.

Eupeodes braggii n. sp.

Length, 8 to 10 mm. Eyes bare; face whitish yellow with a black median line which extends from oral margin but does not reach the antennæ. Cheeks black. Front in male wholly yellow with black pile; front in female black, fading to light yellow towards the antennæ; occiput silvery pollinose, with whitish pile; a brownish crescentic spot above the antennæ. Thorax bluish or dark metallic green with pale yellowish pile; scutellum in both sexes translucent, greenish reflection; posterior margin distinctly yellow. Abdomen sub-opaque, with light colored pile; first segment and posterior portion of all segments shining. The second segment bears two oblong yellowish, attenuated, spots which are contiguous with lateral margins of abdomen. Segment three and four, each with a pair of slightly arcuate yellowish spots, which are separated from the lateral margin of the abdomen, inner angles rounded, outer anterior angles acute. Posterior portion of segments four and five narrowly margined with yellow. Legs yellow, or brown; femora black at base; wings hyaline.

Habitat: Seven specimens, 2 ♂, 5 ♀, Grand Junction, Fort Collins, Colorado. L. C. Bragg and G. P. Weldon, collectors, September 8, 1908.

Eupeodes weldoni n. sp.

Length, 10 mm. Eyes bare, face whitish, white pilose, with a black median line, extending from oral margin almost to the base of antennæ; cheeks black, upper front in female black, lower part yellow, with or without brown crescent-shaped spots above the roots of the antennæ. Vertex greenish, with light colored pile; occiput light with light pile. Antennæ varying from reddish brown to black. Thorax blackish metallic green, with pale yellowish pile; scutellum in female more or less translucent with yellowish pile and distinctly margined with yellow; abdomen black, sub-opaque; thinly pilose with whitish and black pile. The first segment and posterior portion of the second and third shining black; posteriorly, the fourth and fifth marginate with yellow; the fifth also yellow laterally, giving a complete yellow

border. Abdominal spots distinctly yellowish-white, those on the second segments transverse, and reaching the lateral margin. The spots on segments three and four arcuate, attenuated at their tips, and reach the lateral margin anteriorly, venter very pale yellow. Legs yellowish, with white pile, bases of femora black; wings hyaline.

Habitat: Three specimens (♀), Grand Junction, Fort Collins, Colorado. G. P. Weldon, Collector, August 14, 1909.

Syrphus flukei n. sp.

Length 8 mm. Face bluish yellow, only slightly pollinose, a bluish median stripe from roots of antennæ to oral margin. Oral margin brownish, shining; cheeks black, opaque, front dusky yellowish with yellow pile; frontal triangle slightly prominent, whitish pollinose, with black pile. Antennæ brownish red, a dash of wine red at roots of each, and light yellow lines running obliquely from them; third joint ovate, yellowish at base; arista brown, bare; eyes bare, contiguous; thorax shining metallic greenish yellow, with yellowish pile, dorsum with ramifying fern-like ferruginous markings, darker on margins, scutellum yellowish, clearer on margin, semi-translucent, covered with rather abundant long white pile.

Abdomen black, chiefly opaque, with three pairs of yellowish arcuate cross-bands, all reaching the margin; first segment wholly shining. Posterior margins of segments three, four and five, shining; first pair of abdominal spots semi-ovate with attenuated tips which reach the lateral margin only at extreme apex of the first third of segment, second and third pairs distinctly arcuate, with attenuated tips reaching lateral margin at junction of segments, inner angles extending forward and rounded, fourth segment with a narrow yellowish hind margin. Segment five entirely yellow. Legs brownish yellow; femora with rather long yellowish pile, base black, tarsus and metatarsus brownish. Wings hyaline, sub-costal cell brownish, stigma distinctly yellowish.

Habitat: One specimen, Fort Collins, Colorado, May 7, 1915. On plum blossom. Chas. Fluke, Collector.

Syrphus marginatus n. sp.

Length, male, 12 mm. Face yellow with a slight bluish tinge, shining, a brown median stripe from oral margin not reaching the antennæ; cheeks bluish black, shining, the oral margin anteriorly, connecting under the oral opening with the color on the opposite side; frontal triangle yellow, with black pile, greyish pollinose; a slender black or brownish arch above the base of the antennæ; vertical triangle small, metallic blue, with black pile; antennæ brown, along the underside more or less reddish, first two joints lighter than the third; third joint oval; eyes bare; thorax metallic green with moderately thick light pile; scutellum translucent yellowish, shining, with bluish opalescent reflection, chiefly light pile. Abdomen black, principally shining, with three pairs of yellow spots. The first pair transverse,

elongate oval with attenuated tips anteriorly which reach the lateral margins of the abdomen, inner angles rounded; the second and third pairs arcuate, a little oblique, convex behind, concave in front; outer margins acute and directed forward, the inner angles rounded. The fourth and fifth segments with a narrow yellow hind margin, the fifth with two yellow basal marginal spots; legs yellowish with base of femora black; hind femora with more black than the rest; hind tibiae and all tarsi brownish, lighter below. Wings hyaline, stigma brownish.

Habitat: Two males, Fort Collins, Colorado. L. C. Bragg, Collector. May 10, 1911.

NOTE:—*S. marginatus* differs from *S. arcuatus* in that the abdomen of the former is velvety black and sub-opaque, while the latter is principally or wholly shining, and that the abdominal spots are dull yellow and the first pair reach the lateral margin of *marginatus*, while the spots of the latter are bright yellow and are all separated from the margin.

Syrphus meadii n. sp.

Length, male and female, 10 to 12 mm. Face pale yellowish, with a shining black median stripe extending from oral margin but not reaching the antennæ; cheeks shining black, (from eye to oral margin); antennæ reddish brown, lighter on under side; frontal triangle yellow, pollinose, black pile; in the female with a medial black line resembling an inverted Y, slightly convex. Immediately above the antennæ are two large black spots; frontal triangle in the male yellow, silvery pollinose, and with black pile; vertical triangle black, black pile, eyes bare; occiput in the female rather broad, silvery pollinose, and with whitish pile; very narrow in the male.

Abdomen black, principally shining black and yellow pilose, three pairs of yellow cross-bands; the first abdominal cross-band distinctly interrupted and separated from the lateral margin, semi-oval, the inner angles rounded, the latro-anterior angles slightly acute. Second and third abdominal cross-bands coarctate in the middle; a brownish medial mark in the middle of these bands giving them the appearance of being subinterrupted. These bands are concavo-sinuate anteriorly and convexo-sinuate posteriorly. They do not reach the lateral margin and are cut off obliquely forming a sharp angle anteriorly and are rounded posteriorly. The fourth and fifth segments have a narrow yellowish posterior border; fifth segment with two small yellowish triangular spots at its base. The four anterior femora brownish with a black base, the black extending about one-third the length of femora; hind femora black with exception of apices which are brownish; tibiæ brownish, tarsi brown on underside, darker on top. Wings hyaline, subcostal cell brownish, darker at stigma.

Habitat: Eight specimens, seven females and one male. C. S. Mead, Fort Collins, Colorado, June 12, 1913.

Syrphus medius n. sp.

Length, 10 mm. Face yellowish, yellowish pilose, with a distinct blackish brown stripe in the middle, which begins at the oral margin, but does not reach the antennæ. Eyes bare. Antennæ brown, third joint lighter on the under side. Cheeks brownish black, separated from oral margin by a yellowish border completely cutting off the connection between the black on both sides (as in *S. americanus*). Front brownish yellow, with a slight greenish reflection, a darker median furcate line running from the vertex to the base of the antennæ, forming an inverted Y; lighter on sides, with black pile, a shining black spot above each antenna; vertex shining black, black pilose. Thorax bronze, shining, with fine yellowish pile; scutellum lighter, with the same colored pile; abdomen black, with three uninterrupted yellow cross-bands. The first abdominal cross-band entire; anterior margin distinctly concave; posterior margin gently sinuate, having a medial diameter of about one-half of that of the distal ends. The anterior margin extends directly to lateral margin of the body, while the posterior is cut obliquely a short distance from the tip and reaches the lateral margin in half its width. The bands of the second and third segments are equal in width throughout; both have a median anterior and posterior projection; attenuated at the ends and reach the lateral margins in the same manner as the first cross-band; fourth segment with a narrow yellow hind margin; fifth segment yellow, with a narrow transverse blackish spot in its middle; legs yellow, coxæ black, hind femora with a distinct brownish ring on the distal half, all tibiæ and tarsi yellow. Wings hyaline, stigma yellowish.

Habitat: Fort Collins, Colorado, one specimen. L. C. Bragg, Collector, August 22, 1911.

S. medius differs from *S. abbreviatus* in having the distinct brown stripe in the face; the brownish spots above the antennæ, the cross-band on the second segment entire, the cross-band of the third and fourth segments not all convex, sinuate, and the black color of the cheeks separated on the under side of the face by the yellow margin round the mouth.

S. medius differs from *S. americanus* chiefly in that the three principal yellow cross-bands attain the lateral margins of the abdomen.

Syrphus similis n. sp.

Length, 12.5 mm. Eyes globose bare, face yellowish, with bluish tinge, whitish pollinose and with sparse yellow pile; frontal triangle whitish pollinose, with two shining black spots above antennæ; the pile, and that of the vertex, black; vertex shining, metallic greenish; a brownish median stripe from vertex to black spot above antennæ; occiput broad, sides parallel, silvery pollinose, with rather abundant stubby, whitish pile; antennæ brownish, third joint oval, blackish at tip, with brown base; cheeks broad, yellowish. Thorax a dull, slightly shining black, with abundant light colored pile, and a bluish dorso-median

stripe; scutellum light yellow with chiefly black pile; pleura with a tuft of long yellow pile; halteres lemon yellow; abdomen black, opaque, principally black pile, first segment entirely shining, lateral margins of second, third and posterior portion of third and fourth shining. The three pairs of yellow stripes reach the lateral margins. The first pair, semi-ovate, attenuated laterally and rounded on inner angles; second and third pairs semi-rectangular, inner margins rounded, sides parallel, about two-thirds their length, thence slightly curved anteriorly and slightly attenuated, meeting the margins at the junction of preceding segment. Posterior margin of fourth and fifth segments bordered with a yellow transverse line; legs slender, yellowish, with chiefly black pile; bases of all femora black, all tibiæ yellow, inner margins of metatarsi of the front legs yellow, middle and hind metatarsi and tarsi brownish black; wings hyaline, yellowish at base, sub-costal cell brownish, darker at stigma.

Habitat: One specimen, female, Estes Park, 7600 ft., July 15, 1912, G. P. Weldon, Collector.

S. similis differs from *S. torvus* in that the eyes are globose and completely bare; and from *ribesii*, in that the femora are black at the base, while in the ♀ of *ribesii* they are yellow; and in that the abdominal bands are almost straight and attenuated, and that these spots show no convexity until they reach the point where the attenuation begins; from the rounded inner margins of the transverse bands up to the point of attenuation the abdominal spots are almost quadrate.

Sphaerophoria interrupta n. sp.

Length, ♀, 8 mm. Front black, shining, with a black median dash from the vertex, gradually becoming constricted in the middle to a little more than one-half its width, thence gradually broadening to its extreme width, and then tapering to a point above the antennæ; sides silvery pollinose, yellowish above the antennæ, with black and yellow pile; face pale yellow, with white pile and silvery pollen, except on the tubercle; oral margin narrowly brownish; cheeks yellow, with a dark brown spot; antennæ brownish, third joint rounded; arista slightly darker; occiput silvery pollinose, and with white pile; dorsum of thorax metallic greenish black, shining, with a distinct slightly interrupted spot at the base of the scutellum, the same shape and color of the scutellum, but slightly smaller; the anti-sutural stripe broad, yellowish, covered with whitish pollen, which gives it a bluish reflection; the post-sutural, slightly narrowed, entirely yellow, and terminating in an acute angle near the scutellum; pleuræ black, with silvery pollen and white pile; scutellum yellow, translucent, with sparse whitish pile; abdomen black, shining, with four yellow, interrupted cross-bands which reach the lateral margins; the first segment black; with inconspicuous yellowish side spots; second segment with two, semi-triangular, arcuate spots, which reach the lateral margins near the anterior portion of the segment,

inner angles acute; segments three, four and five each with a quadrate, interrupted transverse cross-band on the anterior portion, which reach the lateral margins in their full width, their inner angles slightly rounded; segments four and five narrowly margined, posteriorly, with yellow; legs brownish-yellow; four anterior femora with a brownish band near the middle; tibiæ and tarsi yellowish; hind tibiæ, tarsi, and femora, except at the bases and extreme apices, brownish; wings hyaline, stigma yellowish.

Habitat: One ♀, Happy Hollow, Colorado. C. S. Mead, Collector. August 13, 1913.

Brachyopa rufiabdominalis n. sp.

Length, 7 mm. Face light reddish brown, prominently produced forward, with light, silvery, glistening pollen and very fine white pubescence; slightly concave beneath the antennæ; frontal triangle shining, prominent, with or without a median suture. Cheeks a little darker red than the face and with a shining stripe from the eye to the oral margin; sparsely covered with long white pile. Antennæ situated on a semi-conical projection, of the same general color as the face but slightly darker; first joint about half as long as the second, of a slightly deeper red than the third, dorsally with a tuft of black hairs on each, third joint light red, about as long as first and second together, ovate; arista bare, dorso-basal. Vertex black, frontal portion with or without silvery pollen, eyes narrowly separated. Dorsum of thorax brown with black pile, covered with grayish pollen, anteriorly with two approximate dorso-medial blackish stripes, laterally, with a broad interrupted stripe; the transverse suture deep, shining; humeri with a reddish spot; pleuræ reddish brown; a reddish brown stripe extending from the scutellum to the base of the wing. Scutellum light reddish brown, beset with blackish and reddish pile, shining, with a very narrow median light stripe; abdomen slightly longer than the thorax, but little longer than wide, light reddish brown and entirely shining, with reddish pile; the posterior portion of segments one, two and three with a narrow, posterior, shining, brownish, transverse band, either entire or interrupted in the middle.

Legs of the same color as the abdomen, principally with light colored pile; on the under side of the hind femora and the apex of the four middle femora with stout black pile; tarsi darker brown; light at apex; the hind metatarsi slightly thickened at base and thence gradually tapering to apex; wings hyaline with a reddish tinge, anterior cross-vein before the middle of the discal cell and almost rectangular.

Habitat: Two male specimens. C. R. Jones, Collector. Rist Canon, Colorado, on wild plum. May 12, 1915.

B. rufiabdominalis differs from *B. cynops* in that the scutellum and abdomen are entirely shining, in that, in the former, the circular abdominal and the triangular spots of segments two and three are wanting, and it has the narrow posterior cross-band, and the lengths are different; in that the hind femora and

the apex of the anterior femora have stout black pile, and in that the posterior cross-vein is about two-thirds of the penultimate sections of the fourth vein, instead of being equal.

B. rufiabdominalis differs from *B. vacua* in the color of the thorax and its markings. *B. vacua* has three brown stripes and *B. rufiabdominalis* has four, two entire and two interrupted. *B. vacua* is 8–9 mm. and *B. rufiabdominalis* is 7 mm.

B. rufiabdominalis differs from *B. bicolor* Fallen, of Europe, in that the occiput of the latter is pale gray and with gray pile, the face is without pubescence, the eyes touch for about one-third of the distance from the ocelli to the antennæ; the scutellum has eight long black marginal hairs and is covered with short black pile, while in the former the occiput is black, whitish-pollinose and has black and white pile; the face has fine whitish pubescence on it; the eyes are distinctly separated, the nearest point of contingency is immediately below the ocelli; the scutellum has black pile dorsally, and the remainder is covered with reddish pile and lacks the eight black marginal bristles.

Volucella rufomaculata n. sp.

Length, ♀ 14 mm., ♂ 15 mm. Face yellowish chestnut, thickly clothed with a medium long, yellow pile; separated in both sexes by a narrow yellowish strip. Considerably excavated and bare below the antennæ. Cheeks shining black, black pilose, in the female with a small yellow triangular spot near the eye; in the male this spot connects with the narrow yellow stripe next to the eye. Antennæ reddish brown, lighter at tip, third joint elongate, widest at the base. Arista more than twice as long as the antenna, reddish, with long abundant feathery, black plume; front of the female distinctly yellow, rather narrow, converging at the apex with abundant long, yellow pile. Front of the male brown, shining, sparsely covered with whitish pile, frontal triangle of the male very small, yellow, with abundant long, yellow pile. Eyes of the female sparsely pilose throughout, in the male thickly pilose. Dorsum of thorax, bright shining blue with moderately long black pile. Anterior, lateral margins, posterior margin and pleura with abundant long, yellow pile. Scutellum light-yellow with abundant long, yellow pile. Abdomen shining black with yellow pile, more abundant on lateral margins of second and fourth segments. First segment black, shining, second segment with a pair of large, yellow lateral triangular spots connected on posterior margin with a reddish band, pile of the sides abundant, in the middle sparsely pilose. Third segment with a large red, dorso-medial spot, extending from the anterior margin about two-thirds of the length of the segment, narrowly interrupted in the female and slightly more interrupted in the male, with short erect reddish pile; laterally from this spot, in the female, with yellow pile,

in the male, black pilose, segment four with entirely yellow pile, in both a small black shining spot in the middle shows the ground color. Legs black, with stout black pile, tips of femora, bases of tibiæ and tarsi reddish brown. Wings with a brownish tinge, decidedly colored along the veins.

Habitat: One male; 1 female, C. R. Jones and C. S. Fluke, Collectors, Estes Park and Poudre Canon, August, 1915.

V. rufomaculata differs from *V. evecta* in the color of the thorax, the latter being black and the former being blue; the eyes of the female in *V. rufomaculata* are pilose throughout, and in *V. evecta* they are bare or at most pilose near the top; the abdomen, outside the second segment, in *V. evecta*, is entirely shining black, while in *V. rufomaculata* it has a large, red dorso-medial interrupted spot.

Mallota flavoterminata n. sp.

Length, ♂ 13 mm., ♀ 15.5 mm. Eyes bare, narrowly separated in the male; frontal triangle of the male thickly covered with grayish pollen, whitish pile along the sides and top. Front of the female narrowed above, greenish black, shining, with yellowish pile and a narrow stripe of grayish pollen on each side below the ocelli. Face, deeply concave below the antennæ to the tip of prominent tubercle; from tubercle to oral margin almost perpendicular; on the sides densely covered with grayish pollen. The broad, black median stripe is one-third the width of the face, wholly shining. Pile in the male, silvery, sparse, and rather long; in the female, short, whitish, mixed with golden yellow; the pollinose stripe in both sexes runs to the oral margin. Cheeks black, shining; antennæ brownish-black, the third joint covered with grayish pollen, a little wider than long; arista reddish, dorsal. Dorsum of thorax, in ground color, black with slight gray pollen on humeri, moderately shining, covered with long, thick golden pile. The female more densely covered than the male with a patch of whitish pile at the base of the wings. Scutellum, light yellowish, with the same colored pile as the thorax, but more dense and longer. Pleura with grayish pollen and long, light yellow pile. Abdomen, obtusely conical, shining, first segment with yellow and black pile, second and third with short, stout, black pile; the posterior margin of segments with a transverse band of yellowish pile; fourth segment shining, in the male, reddish brown with wholly yellow pile, more dense laterally; fifth segment reddish brown, sparsely pilose, fourth and fifth segments of the female black, shining, with yellow pile. Legs of both sexes black with black and white pile, the tarsi dark reddish, last joints and base of tarsal claws fuscus; hind femora in both sexes much thickened; hind tibiæ compressed arcuate. Wings hyaline with a distinct brown picture.

Two specimens, one male, C. S. Mead, Poudre Canon, Fort Collins, Colorado, 1913; one female, A. Maxson, on beet blossoms, Longmont, Colorado.

M. flavoterminata differs from *M. Sackeni* in that the marginal cell of the former is open and in the latter it is closed. The pile of the fourth and fifth segments in the former is the same color as the thorax, and not blackish as in *M. Sackeni*. *M. flavoterminata* differs from *M. cimbiciformis* in that the males are dichoptic, the pile and color of the abdomen and the brown spot in the wing.

Mallota palmeræ n. sp.

Length, ♂, 11-12 mm. Eyes bare, converging a short distance below the ocelli. Frontal triangle and vertex separated by a distinct transverse suture, frontal triangle with whitish pile, thickly covered with white pollen, a shining brown stripe above the antennæ. Face deeply concave from the base of the antennæ to the tip of the tubercle, slightly receding, thickly covered on the sides and below the antennæ with whitish pollen, leaving a black bare, median, shining stripe, about one-fifth the width of the face, pile whitish, and rather long on the sides; vertical triangle slightly darker than the frontal, and with moderately thick long white pile. Cheeks shining black. Antennæ brownish black, situated on a brownish truncated process; third joint lighter, rounded and covered with whitish pollen; arista reddish. Dorsum of thorax in ground color, black, moderately covered with whitish pollen which gives the appearance of two light colored abbreviated longitudinal lines. Pile abundant, short, and light yellow. Scutellum yellowish, shining, with fine yellowish and whitish pile. Abdomen long, narrow, obtusely conical, of a dark-brownish color, shining, and with light colored pile; first segment densely covered with white pollen and moderately long, whitish pile; second segment with a pair of brownish, rather indistinct, median transverse triangular spots which reach the lateral margins and are separated medially; the posterior portion narrowly margined with brown. The following segments similar to segment two, but the brownish portion less conspicuous. Legs blackish, with whitish pile, all tarsi apex of hind femora and hind tibiæ brownish, a tuft of stout brownish hair underneath the apex of hind tibiæ, hind femora considerably thickened in the male, arcuate, hind tibiæ arcuate. Wings hyaline, with a distinct brown spot from the base of the discal cell to beyond the anterior cross-vein.

Habitat: Two males, one, C. S. Mead, collected on buckwheat, Fort Collins, Colorado. C. R. Jones, Platteville, Colorado, taken on *Dichrophyllum marginatum*, June and August, 1915.

Xylota nigromaculata n. sp.

Length, ♀, 10 mm.; ♂, 8 mm. Head black, front considerable excavated below the antennæ, oral margin projecting; face blackish, light pollinose, pile whitish; cheeks black, shining, and white pile; front of female narrowed above, black, with two dashes of light pollen somewhat

remote from the eyes; front of the male black, with light pollen; antennæ short, fuscus, rounded; third joint scarcely longer than broad; arista bare, somewhat basal, reddish brown, lighter at tips; thorax metallic green, with short whitish pile, three dorso-medial cinerous stripes extending the entire length of thorax, the medial one about one-half the width of the others, meta-thoracic portion with additional cinereous stripes; scutellum the same color as thorax, with white pile, thicker and heavier on margin; abdomen bluish black, shining with whitish pile; second segment with triangular, metallic, greenish, shining side spots; legs nearly black, hind femora much thickened, hind tibiæ arcuate, reddish at apex, base of all tibiæ somewhat lutescent; front tarsi cinereous, inner margin of middle tibiæ with long whitish pile; wings blackish brown, stigma brown, anterior cross-vein oblique, wholly or partially surrounded by a black spot.

X. nigromaculata differs from *X. metallifera* to which it is closely related, in that the abdomen of the former is steel blue, shining, and has triangular metallic, greenish, shining side spots on the second segment; while the latter is opaque black; and in that the abdomen of the former does not have the elongated oval spots that occur in the latter. The former has distinctly thickened hind femora and the hind tibiæ are arcuate. These characters do not appear in the description of *X. metallifera*. I do not know of any specimens of the latter besides the types and these were unobtainable, so the description was all that was consulted.

Three specimens, two females and one male, Fort Collins, Colorado. The male was taken by S. A. Johnson at apple blossoms and the two females were reared from pupæ taken from an old decaying stump by E. C. Hotchkiss, April 21, 1903.

The following syrphid could not be exactly placed. In the key, it came nearest to *Xylota*, but the generic description did not fit, so, for lack of a better name, I have called it *Microxylota* and the species, *robii*.

Two specimens, Fort Collins, Colorado. C. S. Mead, Collector.

Microxylota n. g.

Small species, 6.5 to 7 mm., slender, metallic; head hemispherical, slightly broader than thorax; antennæ situated on slight conical projection, first two joints short, third more or less oval; arista dorsal, bare; face concave in profile, epistoma slightly projecting; eyes pubescent, contiguous in males; thorax rather large, metallic green; scutellum metallic green, thinned along border; abdomen slightly narrower than the thorax; metallic greenish black, shiny, flattened, sides nearly

parallel. Third segment slightly contracted (viewed dorsally); legs short, rather stout, hind femora short, decidedly thickened, moderately pilose with long golden hairs; hind tibiæ thickened, slightly arcuate, with a few stout spines at apex; metatarsi thickened. Marginal cell of wing open, third longitudinal vein gently curved, anterior cross-vein oblique, beyond middle of the discal cell. The fourth section of the fourth longitudinal vein zigzag with two stump veins projecting outward.

Type of genus *Microxylota Robii.*

Microxylota robii n. sp.

Length, 6.5 to 7 mm., face black with moderately thick, pale, yellowish pile, front narrow above, black, with silvery pollinose and sericeous pile; cheeks shining black; vertex shining black, black pile; eyes contiguous for a short distance, sparsely pilose; occiput shining black, extending broadly backwards; antennæ fuscus, pollinose, third joint rhomboid, somewhat pointed at tip; arista dorsal, bare, brownish. Dorsum of thorax shining, metallic greenish black, with two pollinose tapering stripes running from anterior portion to about middle of thorax, yellowish pilose; scutellum same color as thorax, thinned at the edge. Pile sparse, short, yellowish; abdomen approximately one-third longer than thorax; shining metallic greenish black, only four visible segments from above, sides nearly parallel, slightly tapering from anterior portion of second segment to the tip of abdomen; segments two, three and four with latro-medial, opaque, crescentic, whitish, pollinose depressions. Second segment broad, third slightly contracted; fourth rounding at tip, pile short, yellowish; legs strong, black, hind femora extremely thickened, shining black, with short, yellowish pile, tibiæ gradually dilated from base to apex, arcuate, base reddish brown, tarsi reddish brown; hind metatarsi incrassated at base, gradually tapering to apex. Wings sub-hyaline, stigma brown. The apical bounding vein of the first posterior cell zigzag with two stumps of a vein projecting forward.

Two specimens, males, collected by C. S. Mead, Fort Collins, Colorado, June and August, 1915.

Notice.

It is very important that I have a complete list of our members who are in the army and navy during the war. While we can hardly hope to reach them with the Annals, we may devise a way to keep in touch with them. As it will probably happen that many of them will not see this notice, I request their friends or former teachers to send me their names; it will be better for me to get a name two or three times than not at all.

J. M. Aldrich,
Secretary-Treasurer.

West Lafayette, Ind., June 1, 1917.

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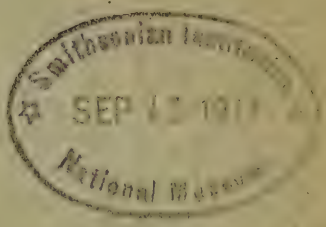
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OBSERVATIONS ON THE PUPAL WINGS OF NEPTICULA, WITH COMPARATIVE NOTES ON OTHER GENERA.

By Annette F. Braun, Cincinnati, Ohio.

The Nepticulidæ possess some conspicuous characteristics not present in other Lepidoptera. The most noticeable of these are the crowding together and anastomosis of the main tracheal stems of the fore wings and the absence of true cross-veins (except the humeral cross-vein in rare instances). The nearest approach to this type of venation seems to be found among certain small Trichoptera; where however the base of media remains distinct and does not anastomose either with radius or cubitus. The presence of a true frenulum in the male in even the most primitive genera of Nepticulidæ taken in conjunction with the fact that in the female we find both jugum on the fore wing and series of hooked spines on the costa of the hind wing also suggests their relationship to the Trichoptera. Other characteristics, such as the presence of the jugum in the female of the more primitive genera, the structure of the mouth parts, and the structure of the pupa ally them to the Eriocranid group of the Micropterygidæ.

It is in the development of the venation of the fore wings that this group differs so strikingly from other Lepidoptera. The disappearance of the basal portion of media takes place through coalescence with the base of radius or with the base of cubitus, and not through atrophy as is usual in the Frenatæ.

In the hind wing media coalesces with radius to about the middle of the wing in much the same way. This condition is not however unique, as it is occasionally present in other groups

among genera with degraded venation. In some apparent examples of media coalescing with radius, a study of phylogeny within the group will show that the result is due to the atrophy of the base of media and the approximation of the remaining one or two branches of media to the radial sector.

Within the genus *Nepticula* we find two types of venation in the fore wing. In one, probably the more primitive, media coalesces with cubitus for a short distance from the base, then passes obliquely to radius just beyond R_{2+3} and anastomoses with radius to beyond the middle of the wing. In the second type, media coalesces with radius from the base to beyond the middle of the wing. In the first type, the oblique portion of media extending between cubitus and radius appears to be a cross-vein and was formerly so interpreted. The occasional persistence of the trachea within the vein cavity of the imago, and studies on the pupal wings, to be presented below, show that this oblique vein is a part of media. Its presence in the imago indicates the coalescence of media with the base of cubitus.

The present paper is based upon studies of pupal wings of two species of *Nepticula*, viz., *N. platanella*, representing the first type of venation, and *N. rosaefoliella*, representing the second type of venation. The persistence in the imagoes of some species, of the shriveled tracheæ within the vein cavities, has made possible comparisons with other genera. Pupal wings of the more generalized forms, which might have thrown some light upon doubtful homologies as noted in the presentation to follow, were not available for study. In the figures of the wings, the single more or less wavy lines represent tracheæ; the even lines enclosing them outline the thickenings which form the future veins. The figures represent the condition of tracheæ and veins a few days before the emergence of the moth.

Fore Wings (Figs. 1, 2, and 3).

Except where otherwise noted, observations on *N. platanella* are based on the pupal wing illustrated by Figure 1.

Costa.—In *N. platanella* (Fig. 2) at a period before the developing vein cavities are clearly defined, the costal trachea is distinct. Later (Fig. 1) it is much shortened and extends

for merely a short distance into the base of the costal vein, not reaching the humeral cross-vein. In *N. rosaefoliella* (Fig. 3) no costal trachea could be distinguished.

Subcosta.—The subcostal trachea is distinct and branched near its tip in *N. platanella;* Sc_1 (except early as shown in Fig. 2) is shriveled and curled even in the pupa, while Sc_2 passes straight onward to the margin of the wing. There is no indication of branching in the subcostal vein of the imago in which trachea Sc_2 extends to the end; the shriveled stump of Sc_1 occasionally persists within the subcostal vein. In *N. rosaefoliella,* the subcostal trachea is unbranched, that portion persisting being Sc_2. The humeral cross-vein is easily visible in *N. platanella,* and I have found it present in all specimens examined; it passes obliquely from subcosta to costa near the base. In the imago it arises almost at the base of the wing, so oblique as almost to seem a proximal prolongation of costa.

Radius.—With the exception that R_{2+3} is represented by an unbranched trachea, the tracheation in *N. platanella* approaches closely to that of the hypothetical type. The tracheal stem of radius branches dichotomously, about half way between the base of the wing and the point of separation of vein R_1 from the main radial stem, into an unbranched trachea R_1, and into a stem which again divides dichotomously, also before the separation of vein R_1, into a second unbranched trachea, R_{2+3} and into R_{4+5}, so that for a short distance the developing vein cavity contains three tracheal branches lying closely along side of one another. R_{2+3} follows R_{4+5} for a short distance before diverging toward the costa. A little beyond the point of separation of R_{2+3}, the trachea of R_{4+5} divides, the branches however lying close together in the same vein cavity until near the apex of the wing, where they diverge, each lying in a separate vein cavity. The relation of tracheæ to veins in *N. rosaefoliella* is in essential agreement with that observed in *N. platanella,* except that (1) the branching off of tracheæ R_1 and R_{2+3} occurs at or near the point of separation of the corresponding veins and (2) there is no division of trachea R_{4+5} until very near the margin of the wing (cf. fig. 3) and but a single unbranched vein is formed.

In the imaginal wing of the European *Trifurcula,* the main stem of the persistent radial trachea divides dichotomously into

R_1 and R_{2+3}; further branches of radius (both tracheæ and veins) are entirely wanting. In the adult wing of the European *Scoliaula*, the separation of vein R_1 occurs at the point of origin of trachea R_1, which is very near the base; otherwise the tracheation of radius, as far as persistent, is similar to that of the pupal wings of *N. platanella*.

Media.—In all species of *Nepticula*, media is represented by an unbranched vein which reaches the wing margin below the apex. In the pupal wings of both species examined, a single trachea extends from base to wing margin, with no discernible trace of branching. In *N. platanella*, the basal portion of this trachea lies within the same vein cavity and alongside of the base of the cubital trachea, from which it diverges to pass obliquely to radius just beyond R_{2+3}, lying alongside of and in the same vein cavity with the radial trachea to beyond the middle of the wing where it again diverges before the separation of veins R_4 and R_5, and passes to the margin of the wing below the apex. In one specimen (Fig. 2), at an earlier stage of development than that shown in Figure 1, and in which the vein cavities were not as well defined, the medial trachea does not approximate as closely to cubitus at its base, nor to radius in the middle of the wing, so that the relative positions of the basal stems of the main tracheæ approach more nearly to those of the hypothetical type. In *N. rosaefoliella*, the trachea of media lies alongside of and in the same vein cavity with radius from the base of the wing to its point of divergence from R_{4+5} beyond the middle of the wing. An intermediate condition is to be noted in *N. variella*, where media coalesces with cubitus at base, but passes to radius before the point of separation of R_1.

Because of the unbranched condition of the medial trachea it is impossible to determine with certainty the homology of the vein which it precedes.

In *Obrussa* and *Glaucolepis* media is two-branched; in the former genus, the separation of the branches occurs beyond the separation of media from R_{4+5}; in the latter before the separation of media from radius. In *Obrussa*, the tracheæ in the imaginal wing are not sufficiently persistent for study. In *Glaucolepis*, the medial trachea is unbranched and shrivels up near the point of separation of the first of the two branches of media. However, as all of the branches of the radial trachea are distinctly

preserved along the middle of the wing, as is also the cubital trachea (which here lies alongside of media for its whole length), it might be expected that if the second branch of media were M_{3+4} it would be represented by a remnant of a trachea branching off about as far from the base as the second dichotomous division of radius, and certainly not farther distad than the separation of R_{4+5} into its branches. No such remnant is discernible and I have therefore interpreted the branches of media in these two genera as M_1 and M_2 respectively.

In the genera *Scoliaula* and *Trifurcula*, in the adult wing, three veins which reach the margin below the apex arise from the main vein traversing the middle of the wing, which, as shown by the persistent tracheæ within the vein cavity, is formed by the coalescence of the basal stems of the radial sector, media and cubitus in *Scoliaula*, and by the coalescence of media and cubitus in *Trifurcula*. The medial trachea so far as it persists is unbranched in both. The first two veins may without doubt, as in the previous case, be regarded as M_1 and M_2, respectively. As far as any evidence presented by the tracheæ is concerned, the third vein may be either M_{3+4} or cubitus. In most other genera, as noted immediately below, cubitus tends to become obsolete before reaching the margin; if the same course of development has been followed here, the conclusion would be that the third vein is M_{3+4}.

Cubitus.—In *N. platanella* the unbranched cubital trachea passes almost straight from base to beyond the middle of the wing, where it becomes obsolete. As before mentioned, in the proximal part of its course, it lies within the same vein cavity as media. In *N. rosaefoliella*, the cubital trachea lies alone in a separate vein cavity. A condition similar to that in *N. platanella* is found in *Ectoedemia* and *Obrussa;* in *Ectoedemia* cubitus usually reaches to the margin, in *Obrussa* it atrophies shortly after its separation from media. In *Glaucolepis* cubitus has entirely coalesced with media in its proximal portion and with the radio-medial stem beyond. In *Scoliaula* the cubital trachea lies in the single vein cavity in which are also the medial and radial tracheæ, and from which R_1 separates near the base. In *Trifurcula* the cubital trachea, which lies in the same vein cavity as media, branches dichotomously at the same distance from the base as the branching of radius; these branches persist to about the middle of the wing.

Anal Veins.—There are two anal veins. The first is here regarded as the homologue of the second anal vein of the hypothetical type, because of its relation to the anal furrow, because it occupies the same position as the second anal vein in other Lepidoptera, and because of its identical structure with that vein in some Trichoptera. In both species studied the trachea is distinctly visible within the developing vein cavity extending almost or quite to the end of the vein; the trachea usually persists in this vein in the imago. The third anal vein is sometimes present. In *N. platanella* it shows merely as a short spur from the base of the second anal vein, in which even in the pupa, no trachea is visible. In *Scoliaula* it is better preserved and portions of the trachea persist.

Hind Wings (Figs. 4 and 5).

Observations on the pupal hind wings were confined to *Nepticula platanella.*

Costa.—No costal trachea was discernible. Figure 5 represents the venation and tracheation in a wing just after emergence. The costal vein is seen to be connected at the base with the subcosta, apparently by a much shortened humeral cross-vein, much as in the fore wing.

Subcosta and R_1.—Early in pupal development the trachea of subcosta and R_1 are widely separated and R_1 leaves the radial stem very near the base, as shown in Figure 4. At emergence they are more closely approximated and enclosed within the same very broad vein cavity. A similar condition may be noted wherever the tracheae persist.

Radial Sector and Media.—The radial sector is reduced to a single unbranched trachea lying in its proximal half in the same vein cavity with the medial trachea. The medial trachea and vein in *N. platanella* are unbranched as is also the case in the other species and genera, except in *Glaucolepis* and *Trifurcula* where the vein is dichotomously branched. In *Glaucolepis* the medial trachea is also dichotomously branched near the base and before the separation of radius and media; one branch running into each of the branches of the medial vein. From this it would appear that the first branch of media is M_{1+2} and the second M_{3+4}. In *Trifurcula* the trachea is single and extends into the first medial branch.

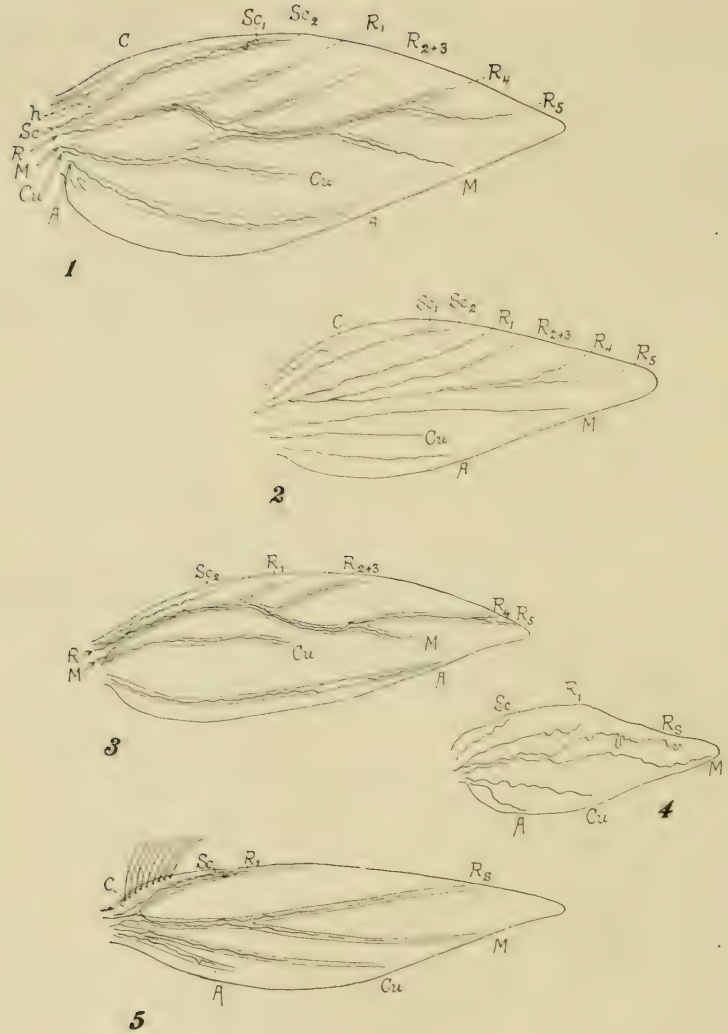
Cubitus.—The cubital trachea is unbranched, and in the earlier pupa extends nearly to the wing margin.

Anal Veins.—At least one anal vein is present preceded by a trachea which often persists in the imago. In some species and genera, a second short anal vein is present, but no trachea persists.

The question of homology of wing veins among forms with degraded venation, as is often the case in the Microlepidoptera, sometimes presents a puzzling problem, which in many cases can only be solved by a study of pupal wings; involving as has been hinted in the above presentation of the pupal wings of *Nepticula*, a study of the more generalized as well as the most specialized wings within the group, since the tracheae show the same tendency toward reduction in number of branches as is seen in the wing veins of the imago.

EXPLANATION OF PLATE XVIII.

Fig. 1. Pupal fore wing of *Nepticula platanella* a few days before emergence.
Fig. 2. Pupal fore wing of *N. platanella* at an earlier stage than that represented by Fig. 1.
Fig. 3. Pupal fore wing of *Nepticula rosaefoliella.*
Fig. 4. Pupal hind wing of *N. platanella* of the same age as the fore wing in Fig. 2.
Fig. 5. Hind wing of *N. platanella* just after emergence.



Annette F. Braun.

THE PHYLOGENY OF THE ELATERIDAE BASED ON LARVAL CHARACTERS.

By J. A. Hyslop, Bureau of Entomology, Washington, D. C.

The object of the present paper is to accentuate the value of studies of the larval characters in attempting a natural classification of the Coleoptera, and to present a new arrangement of the Elateridæ based upon such studies. The paper is preliminary and based largely upon the external characters of the larvæ. Seventy-nine names have been recognized at one time or another for genera occurring in our fauna, but, after considering synonomy and misidentification, this number can be reduced to between forty and fifty. Practically all of the common holoartic genera are represented. Specimens of the larvæ of thirty-eight genera have been studied. The fourteen or more genera whose larvæ are still unknown are as follows: The genus *Melanactes*, containing seven species, two of which are quite common; the genus *Esthesopus*, containing six species; *Paranomus*, four; *Leptoschema*, three; *Oxygonus*, *Eniconyx* and *Meristhus*, two each; and *Nothodes*, *Bladus*, *Elatrinus*, *Blauta*, *Oedostethus*, *Aptopus* and *Coptostethus*, one each. In the absence of reared material, the characters of the genera *Ischnodes*, *Ectinus*, *Adrastus*, *Hypnoidus* and *Lepturoides* were drawn from literature. With these exceptions, the larvæ of species representing all the genera herein treated were examined by the writer and the generic characters drawn from the last larval exuvium of individuals of which the imago was reared and carefully determined. In many of the genera several species were examined.

I wish to express my sincere gratitude to Mr. E. A. Schwarz, of the U. S. National Museum, without whose kindly assistance the work would have been impossible; to the late Professor F. M. Webster, who permitted the use of the material in the Division collection; to Mr. H. S. Barber, who facilitated the use of the Museum material; to Mr. C. W. Johnson, of the Boston Society of Natural History, who very kindly allowed me to use the material in the Thaddeus Harris collection; and to Dr. A. D. Hopkins and Mr. F. C. Craighead, of the Division of

Forest Insect Investigation, for the use of their very valuable material. I am deeply indebted to Dr. Adam Böving, of the same Division, who gave invaluable assistance in homologizing the sclerites in several genera, and who helped in countless other ways, both with material from Europe and his broad knowledge of Coleopterous larvæ.

The principal works consulted were: Schiodte[1] (1861-69), Perris[2] (1852-1863), Candeze[3] (1861), Henriksen[4] (1911), and Gahan[5] (1911), and also the principal works on classification of the adult beetles.

Before proceeding with the classification of the Elateridæ as we now understand this family, I will briefly discuss the older group *Sternoxes* of Latereille[6] (1802). This is still recognized by such renowned authorities as Kolbe (1901) and Gahan (1911) to be a natural super-group. Lacordaire[7] (1857) subdivided this group into six families, the Elaterides, Cerophytides, Cebrionides, Eucnemides, Throscides and Buprestides, which with but few changes, have stood to the present time. Drs. Leconte and Horn (1883) in their classification reduced the Cerophytidæ, Cebrionidæ and Eucnemidæ to subfamilies, erecting an additional subfamily, the Perothopinæ, to include the genus *Perothops* formerly included in the Eucnemidæ, but rejected from that family by de Bonvoluoir in his Monograph. This last author retained the Cerophyidæ in the Eucnemidæ, but Leconte and Horn believed that it should represent a subfamily connecting the Eucnemidæ with the Dascyllidæ. Kolbe (1901) re-established these families, adding the Dicronychidæ which is considered by Gahan (1911) to be very closely related to the Plastoceridæ of the more recent authors and which I reduce to subfamily rank. The classification herein proposed agrees with that of Kolbe[8] (1901) in elevating the Leconte and Horn subfamilies to family rank, but would indicate the relationship of these families by establishing a superfamily Elateroidea.

[1] Metamorphosi Eleutheratorum Observationees, 1861-69. Classification of the Buprestidae and Elateridae (Natur. Hist. Tidssk., Ser. 3, Vol. III, Copenhagen, 1865.

[2] Histoire des Insects du Pin Maritime (Ann. Soc. Ent. France), 1852-63.

[3] Histoire des Metamorphoses de quelques Coleopteres Exotiques, Liege, 1861.

[4] Oversight over de danske Elateridae-larvae (Entomologie Meddelelser, part 2, Vol. IV, 1911.

[5] Classification of the Coleoptera (The Entomologist, Vol. XLIV), 1911.

[6] Hist. Nat. etc. Tome III, p. 99, 1802.

[7] Hist. Nat. des Ins. Col. IV, p. 1-246, 1857.

[8] Arch. fur Naturg. 1901, p. 39.

I do not consider the Buprestidæ as at all related to this superfamily, and have not yet studied the Throscidæ. Mr. F. C. Craighead has very recently loaned me a larval exuvium of *Drapetes geminatus* Say. This species, heretofore referred to the Throscidæ, is certainly very closely allied to the Elateridæ of the subfamily Oestodinæ in its larval characters. Through the kindness of Dr. Böving I have received specimens of *Throscus dermestoides* from Mr. C. E. Rosenberg, of Copenhagen, which are most assuredly not closely allied to the Elateridæ, and conclude that on the present evidence it will be necessary to remove the genus *Drapetes* from the Throscidæ.

The hitherto supposed relationship of the Elateridæ and Buprestidæ, using the Eucnemidæ as the connecting link, is undoubtedly erroneous, the larval resemblance being purely superficial. The characters formerly used to differentiate the Eucnemidæ from the Elateridæ have failed to hold even with the few specimens I have examined. They are not as has generally been conceded, universally apodus as is clearly to be seen in an undoubted Eucnemid larva occurring in rotten logs in the Eastern States, in which distinct, though rudimentary, legs are evident. The mouthparts are adapted to wood boring, so their unique structure cannot be given overmuch taxonomic weight, and the tenth abdominal segment is situated ventrocephalad to the ninth as in the Elateridæ. The careful anatomical studies made by Schiodte[9] (1847 and 1865) of the adults separate the Elateridæ and Buprestidæ very widely. The old group *Sternoxes*, as we now understand it, consists of three groups: the superfamily Elateroidea; the family Throscidæ, part of which may eventually be placed in this superfamily; and the family Buprestidæ. The superfamily Elateroidea embraces the families Cerophytidæ, Cebrionidæ, Plastoceridæ, Elateridæ and Eucnemidæ. The Cerophytidæ and Plastoceridæ are unknown as larvæ. Their very doubtful position cannot fail to be somewhat more positively determined by their larvæ when these are described. The plate (Fig. 1) indicates in outline the various concepts of this complex.

[9] (Naturhist. Tidssk. ser. 3, Vol. III, 1865) and Konge. Danske Viden. Selsk. Forh. 1847).

STERNOXYS LATREILLE.

CONCEPTION OF LACORDAIRE	CONCEPTION OF KOLBE	PRESENT CONCEPTION	CONCEPTION OF GANGLEBAUR	CONCEPTION OF LECONTE & HORN
Fam. ELATERIDAE	Fam. ELATERIDAE	Super Fam. ELATEROIDEA	Fam. ELATERIDAE	Fam. ELATERIDAE
Fam. CEROPHYTIDAE	Fam. CEROPHYTIDAE	Fam. Cerophytidae		Sub. Fam. Cerophytinae
Fam. CEBRIONIDAE	Fam. CEBRIONIDAE	Fam. Cebrionidae	Fam. CEBRIONIDAE	Sub. Fam. Cebrionidae
	Fam. PLASTOCERIDAE	Fam. Plastoceridae		
		Sub. Fam. Dicronychidae		
		Fam. Elateridae		Sub. Fam. Elaterinae
Fam. EUCNEMIDAE	Fam. EUCNEMIDAE	Fam. Eucnemidae	Fam. EUCNEMIDAE	Sub. Fam. Eucneminae
		Sub. Fam. Perothopinae		Sub. Fam. Perothopinae
	Fam. DICHRONYCHIDAE			
Fam. THROSCIDAE	Fam. THROSCIDAE	Fam. THROSCIDAE (excluding *Drapetes*)	Fam. THROSCIDAE	Fam. THROSCIDAE
Fam. BUPRESTIDAE	Fam. BUPRESTIDAE	Fam. BUPRESTIDAE	Fam. BUPRESTIDAE	Fam. BUPRESTIDAE

FIG. 1.

The larvæ of the Elateridæ, as here restricted, are distinguished by the following characters: (1) The lower mouthparts inserted, that is to say, the hypostoma strongly curved caudad and the maxillary stipes and cardo inserted far behind the mandibular articulation. (2) Labrum not defined; it may be aborted or it may be fused with the post-labrum and front into the nasal lobe. (3) Spiracles of the biforian type. (4) Three-jointed antennæ. (5) Well-developed thoracic legs. (6) Unguiform tarsi. (7) Tenth segment ventrocephalad to the ninth. (8) No cerci. (9) Mandibles not perforate as in some Lampyridæ, etc.

Schiodte, using larval characters, divided the Elateridæ, in which he also included our present families Cebrionidæ and Eucnemidæ, into two main groups, basing his conclusions on the presence or absence of anal armature. Group 1 contained the Eucnemidæ and group 2 the Elateridæ and Cebrionidæ. He subdivided his Elateridæ, in the narrow sense, into main divisions A and B, the former embracing *Cardiophorus*, *Chalcolepidius*, *Alaus*, *Agrypnus* and *Lacon;* the latter the remainder of the family as known to him, including the Cebrionidæ. With the exception of the genus *Cardiophorus*, I include all the genera of his division A in my tribe Pyrophorini. He separated his second division into categories on the shape of the ninth abdominal segment. The first of these categories, those species without posteriorly directed paired prongs, includes the genera which I refer to my subfamily Elaterinæ, and the second, in which occur manifestly paired prongs on the ninth abdominal segment, includes the genera referred to the tribe Lepturoidini of my subfamily Pyrophorinæ.

Henriksen follows Schiodte in using the presence or the absence of anal armature to primarily subdivide the Elateridæ into the tribes Agrypnini and Elaterini. This division is not at all natural as it widely separates such manifestly closely related forms as *Limonius* and *Ludius* Esch. (which we have been erroneously calling *Corymbites*) and brings together such distinct tribes as the Steatoderini and Athouini. A much more natural division is based upon the depressed body, visible and membraneous pleural areas, and emarginate ninth abdominal segment; in contrast with the cylindrical, highly chitinized body, concealed pleuræ, and entire ninth abdominal segment.

This conclusion is strengthened by the systematic arrangement of these insects as conceived by the more eminent workers of the group and based almost exclusively on adult characters.

The first, third and fourth tribes of Candeze (1857)* Agrypnides, Hemirhipides, Chalcolepidides, fall naturally under my Pyrophorini. His second tribe, Melanactides, is still unknown in the larval stage and we can expect much light to be thrown upon its phyletic position when the larvæ are described. Candeze states that the tribe serves as a connecting link between the Agrypnides and the Hemirhipides. The type genus of the tribe was established by LeConte (1853) for several North American species placed by Eschscholtz in his *Ludius* and by Germar in *Pristilophus*, both genera now usually considered as *Corymbites* Latr. Whether the larvæ of these insects will show a relationship between my tribes Pyrophorini and Lepturoidini or will reduce the tribe Melanactides to synonomy under one of the other tribes, remains to be discovered. He includes in his seventh tribe, Elaterides vrais, the Pyrophorina and Monocrepidina, which I consider should be placed at the end of the tribe Pyrophorini as the transient forms between the two tribes of this subfamily, and not at all closely related to the other subtribes which he places in this tribe. Excluding these two groups of genera, the tribe Elaterides vrais agrees with the primary division of Schiodte and Henriksen, and may have suggested the high ordinal value that these more recent writers gave to the presence or absence of anal armature. Candeze's division of his two great tribes into subtribes, however, is remarkably illuminating from our view point, in many respects bearing out the conclusions here set forth. His subtribe Ludites includes the tribes Steatoderini and Agriotini of my subfamily Elaterinæ. His Campylites, which he places at the end of his classification and considers very distinct from the other tribes, I place at the end of the tribe Lepturoidini, though undoubtedly many of the genera in the Campylites will be found to belong in other tribes than that of the type genus. In his later work† (1891) Candeze disregarded the two tribes of his Monograph and raised all his subtribes to tribal rank.

* Monogr. des Elat. Tome 1, (1857).

† Cat. Method. des Elat. 1891.

Leconte and Horn (1883) agree with Candeze (1857) in tribal arrangement, except that they reduce Campylites to a subtribe under the Athoui, which I believe to be much nearer to the true position of the genus *Campylus* than that given by Candeze. Their division into subtribes, based primarily upon the shape of the posterior coxal plates, has led them into some very grave errors and seems to indicate that the form of the "plaque nasale" used by Candeze as of primary importance has much higher ordinal value. Their subtribe Corymbitini includes such widely separated forms as *Pyrophorus*, which belongs to my subfamily Pyrophorinæ, *Athous*, belonging to the same subfamily, but tribe Lepturoidini; *Agrypnus*, belonging to the same subfamily, tribe Pyrophorini; *Sericosomus*, belonging to the subfamily Elaterinæ and tribe Steatoderini; and *Melanotus* to the tribe Melanotini. Their subtribe Elaterini includes *Monocrepidius*, of my subfamily Pyrophorinæ, tribe Pyrophorini; *Cryptohypnus*, of the same subfamily but in tribe Lepturoidini; *Tricophorus*, of the subfamily Elaterinæ, tribe Steatoderini; and *Elater* and *Megapenthes*, of the tribe Elaterini.

O. Schwarz (1906) in Genera Insectorum follows Candeze (1891) with but few exceptions. He raises Candeze's Plastocerini to family rank; adds the tribe Octocryptini to receive the single genus *Octocryptus* Candeze; Physodactylini to include several genera from South America and Africa; and changes six tribal names in accordance with the rules of nomenclature.

Pyrophorinæ.

My first subfamily, the Pyrophorinæ, is characterized by having the larvæ (Fig. 2) dorso-ventrally depressed, with the ninth abdominal segment emarginate posteriorly, and the pleural areas membranous and visible; while in the adult the front is usually flat or concave, the "plaque nasale" when present is wide and the antennal fossæ small.

This subfamily is divided into four tribes, the first of which, the Pyrophorini, is characterized in the larvæ (Fig. 2) by having the submentum triangular, bases of stipes-maxillæ contiguous, and mandibles without teeth on the inner surface; and in the adults, by the absence of the cubital cross vein in the wings. This vein is present in all the other groups with but one or two exceptions, which will be mentioned later.

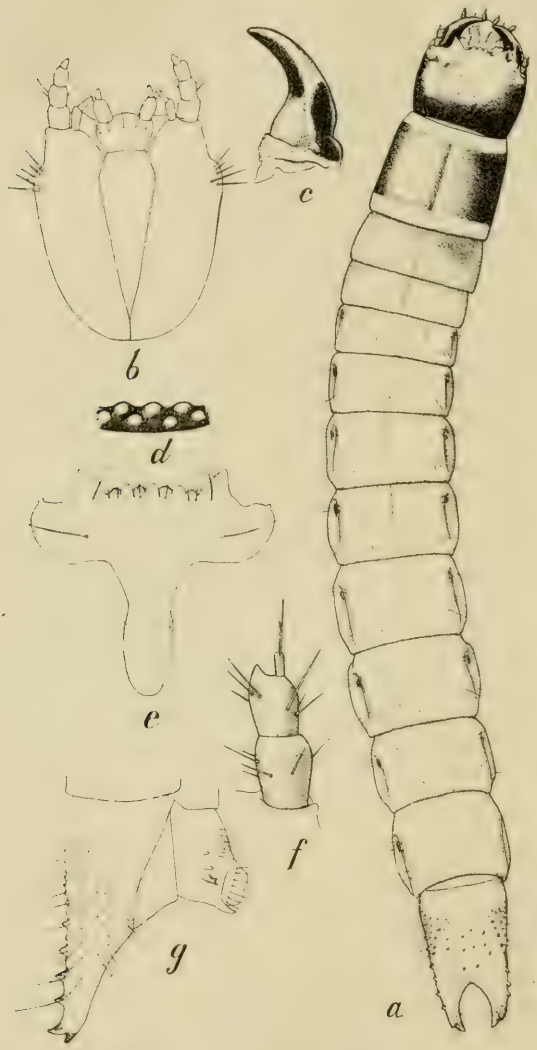


Fig. 2. *Pyrophorus luminosus* Illig. a, dorsal aspect of larva; b, ventral aspect of labium and maxillae; c, ventral aspect of left mandible; d, anterior aspect of nasale; e, nasale and front; f, antenna; g, lateral aspect of 9th and 10th abdominal segments.

The second tribe of the Pyrophorinæ, the Pityobini (Fig. 3), is characterized in the larval stage by having the submentum triangular and the mandibles with three teeth on the inner surface. The adults have flabellate antennæ in the males; a distinct transverse carina on the front above the "plaque nasale;" joints two to four of the tarsi with short

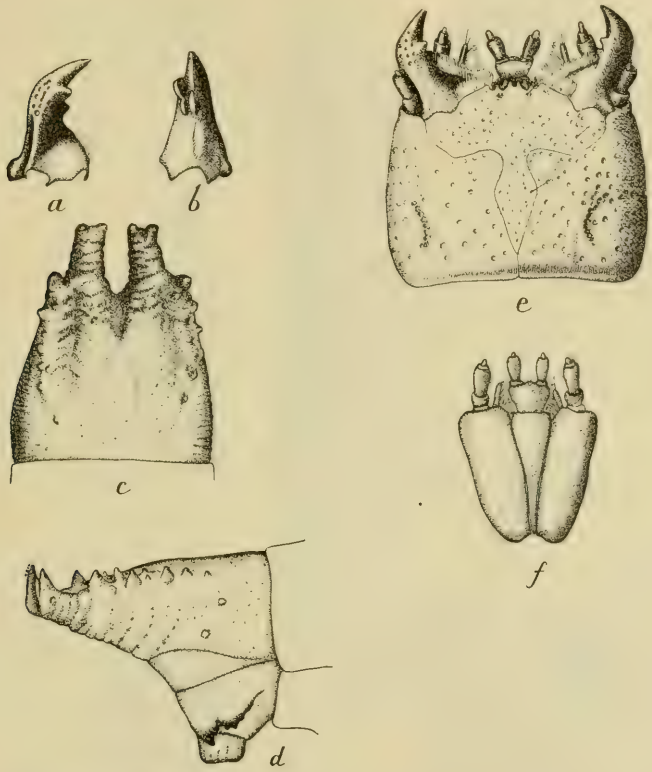


Fig. 3. *Pityobius anguinus* Lec. a, dorsal aspect of left mandible; b, inner aspect of same; c, dorsal aspect of 9th abdominal segment; d, lateral aspect of 9th and 10th abdominal segments, (10th reconstructed); e, dorsal aspect of head; f, labium and maxillae.

lobes and the first tarsal joint longer than the two following joints united. This tribe is of remarkable interest as it is intermediate between the two main subdivisions erected by Schiodte and Henriksen, having the retinaculum of their second tribe and the triangular submentum of their first tribe. This bears out my conclusion that the shape of the ninth abdominal

segment, and general shape of the body, are of higher ordinal value than the presence or absence of anal armature.

The third tribe, Lepturoidini, is easily separable in the larval stage (Fig. 4) from the other two tribes in the first subfamily by having the submentum broad caudad, that is to say, the

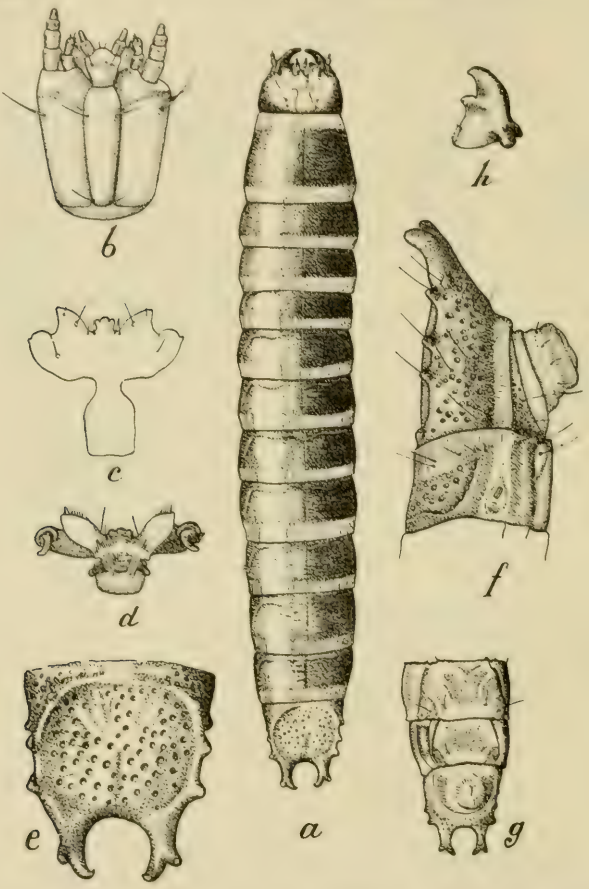


Fig. 4. *Athous cucullatus* (Say). a, dorsal aspect of larva; b, ventral aspect of labium and maxillae; c, nasale and front; d, anterior aspect of same; e, dorsal aspect of 9th abdominal segment; f, lateral aspect of 8th, 9th and 10th abdominal segments; g, ventral aspect of 7th to 10th abdominal segments; h, ventral aspect of left mandible.

stipes-maxillæ widely separated by the posterior part of the submentum; by the absence of armature on the tenth abdominal segment; and by having teeth on the inner surface of the mandibles; while the adults have the cubital cross vein present.

The tribe Oestodini is tentatively placed in the first subfamily but undoubtedly is much more widely separated from the other three tribes than these are from each other and, as has already been mentioned, is very similar to the so-called Throscid, *Drapetes geminatus* Say. The larvæ (Fig. 5) are distinguished

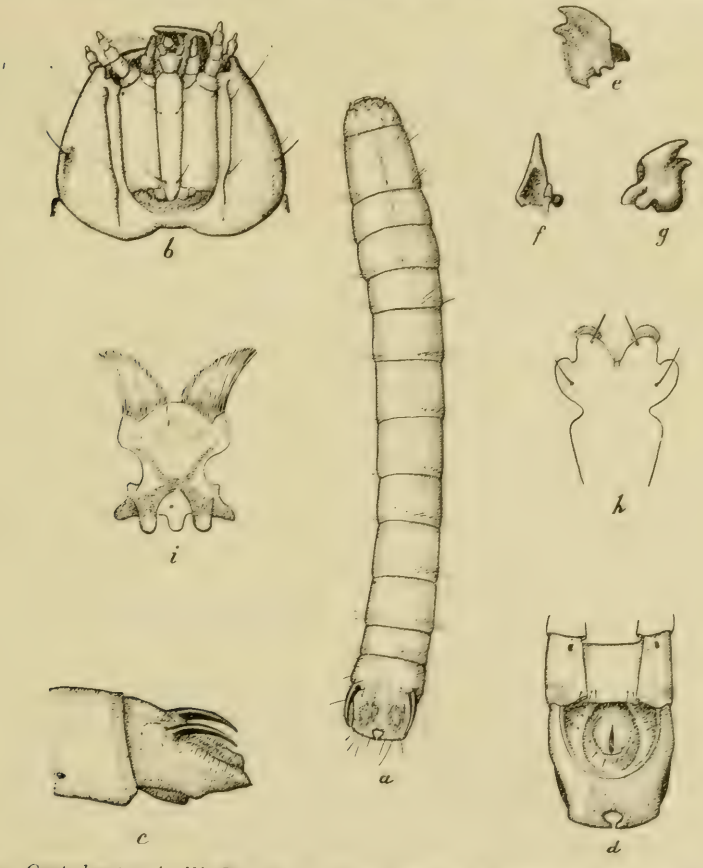


Fig. 5. *Oestodes tenuicollis* Rand. a, dorsal aspect of larva; b, ventral aspect of head; c, lateral aspect of 8th, 9th and 10th abdominal segments; d, ventral aspect of same; e, dorsal aspect of right mandible; f, lateral aspect of same; g, ventral aspect of same; h, front; i, hypopharyngial chitinization.

by the absence of a "nasale," that is to say, the forepart of the fronto-clypeal region is concave instead of being produced into a dentate plate as in all other Elaterid larvæ; the mandibles have a pronounced tooth on the inner edge; and the

ninth abdominal segment bears two caudally directed stout, curved prongs on its dorso-cephalad surface. The adult is characterized by having the prosternum very short anteriorly, thus leaving the under mouthparts exposed; by having the meso-coxæ contiguous; and the front not carinate, in this last respect being very similar to our subfamily Elaterinæ. Heretofore the insect upon which this tribe is established, *Oestodes tenuicollis*, has been placed in the Campylites. This is undoubtedly erroneous. The larva of the type species of the genus *Campylus* has been described by Schiodte (1861-1869) and by Henriksen (1911) and the similarity of this larva and also the adult of the typical *Campylus* and *Athous*, leaves but little doubt that the Campylidinæ (Lepturoidinæ) are not in a tribe by themselves, but very closely related to the Athouina and in no way whatever related to *Oestodes*. It is barely possible that Schiodte did not actually have the larva of *Campylus denticornis* as this insect is certainly easily distinguished from *Athous* on adult characters.

The tribe Pyrophorini includes five generally accepted tribes which are here reduced to subtribal rank. The first subtribe, Agrypnina, is distinguished in the larval stage by the simple anal armature, simple mandibles and triangular submentum. The Hemirrhipina includes the Alaites of Candeze (1891) and the Hemirrhipini of authors. It is distinguished by the simple mandibles in the adult stage and by the presence of the meso-metasternal suture. The Chalcolepidina are distinguished by the absence of the meso-metasternal suture, being the only Elaterids in which this suture is not well defined. This character is of rather questionable value, however, as *Alaus* is so extremely similar to *Chalcolepidius* in many very important characters that it is questionable whether this genus should be placed in the Hemirrhipina or in the Chalcolepidina. Leconte and Horn placed *Alaus* and *Chalcolepidius* in the same tribe, excluding *Hemirrhipus*. The wing venation of the two genera is almost identical; the cubital cross vein arising at the base of the first fork of the cubitus and the radio median cross vein arising at about the middle of the median cell. The Pyrophorina are distinguished from all other Elaterids by the luminous vesicles of the prothorax. The "nasale" in the larvæ has, on its anterior border, seven blunt teeth

arranged in two rows, three in the upper and four in the lower row. The mandibles are simple and the armature of the tenth abdominal segment consists of accessory spines in addition to the anal hooks, found in all the tribe Pyrophorini. The subtribe Monocrepidina is characterized in the larval stage by the triangular submentum; tridentate "nasale;" simple mandibles; decidedly reduced anal armature. This last character showing a transition from the highly complex armature of the tenth abdominal segment of the Chalcolepidina and Hemirrhipina to the unarmed tenth abdominal segment of the Lepturoidini. The adults are characterized by the broadened posterior coxæ, and convex front, which are exceptional characters in this tribe.

The first subtribe of the Lepturoidini, the Athouina, includes *Athous*, *Limonius*, *Pheletes*, etc. The adults have the anterior carina of the front well developed, the posterior coxæ but slightly broadened inwardly, and the tarsal claws simple. The second subtribe, the Ludiina, includes the genera *Cryptohypnus*, *Hypnoidus*, *Ludius* (Corymbites auct.) *Hemicrepidius*, etc. The genus *Cryptohypnus* is exceptional in that the cubital cross vein is absent. The subtribe Lepturoidina includes those members of the old tribe Campylidini which are closely related to the genus *Campylus* as distinguished from those of the *Oestodes* tribe. The three subtribes of the Lepturoidini are not as yet separable on larval characters.

Elaterinæ.

The second subfamily, the Elaterinæ, is characterized by having the larvæ (Fig. 6) cylindrical or subcylindrical in general form, the ninth abdominal segment never emarginate, and the pleural areas always concealed or decidedly reduced; the adults have the front usually convex, the "plaque nasale" narrow when present, and the antennal fossæ large. This subfamily is divided into five tribes: the first, the Steatoderini, includes *Sericosomus*, *Trichophorus*, *Orthostethus*, etc. The larvæ (Fig. 6) have the ninth abdominal segment smoothly ellipsoidal and the tenth abdominal segment extremely small.

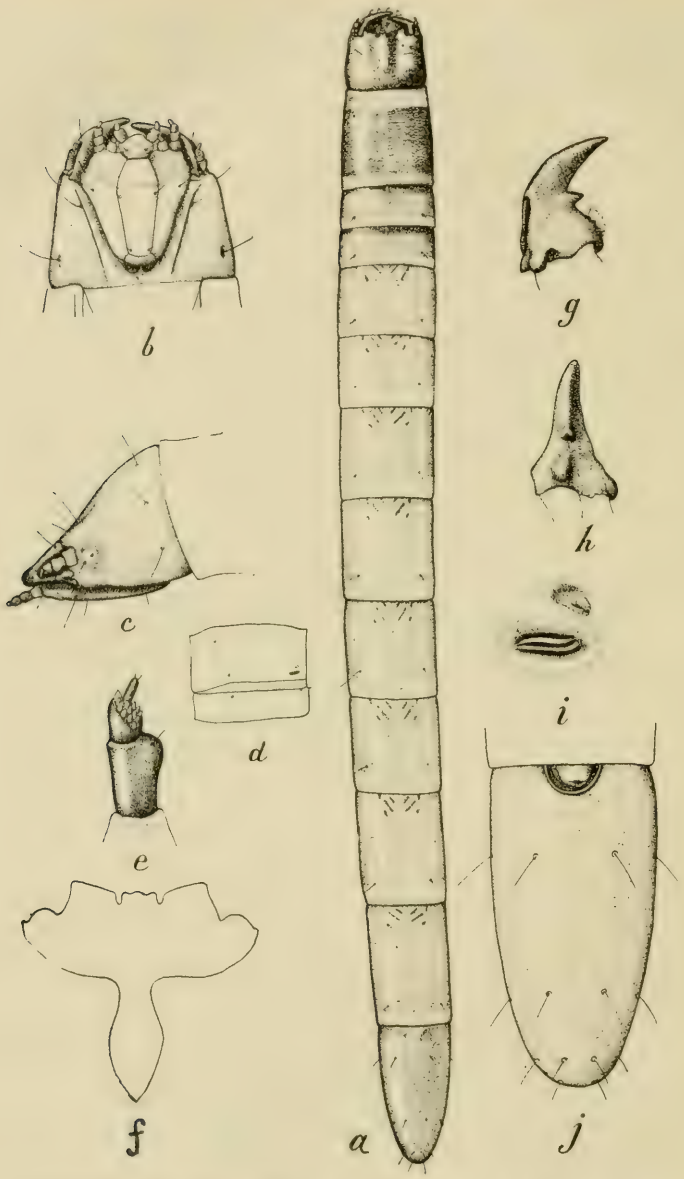


Fig. 6. *Orthostethus infuscatus* Germ. a, dorsal aspect of larva; b, ventral aspect of head; c, lateral aspect of head; d, lateral aspect of abdominal segment; e, antenna; f, nasale and front; g, ventral aspect of right mandible; h, inner aspect of same; i, abdominal spiracle; j, ventral aspect of 9th and 10th abdominal segments.

The second tribe, the Agriotini, includes *Agriotes*, *Dolopius*, *Ectinus*, *Adrastus*, *Betarmon*, etc. The larvæ (Fig. 7) are characterized by having the "plaque nasale" tridentate; the ninth abdominal segment more or less bluntly pointed caudad,

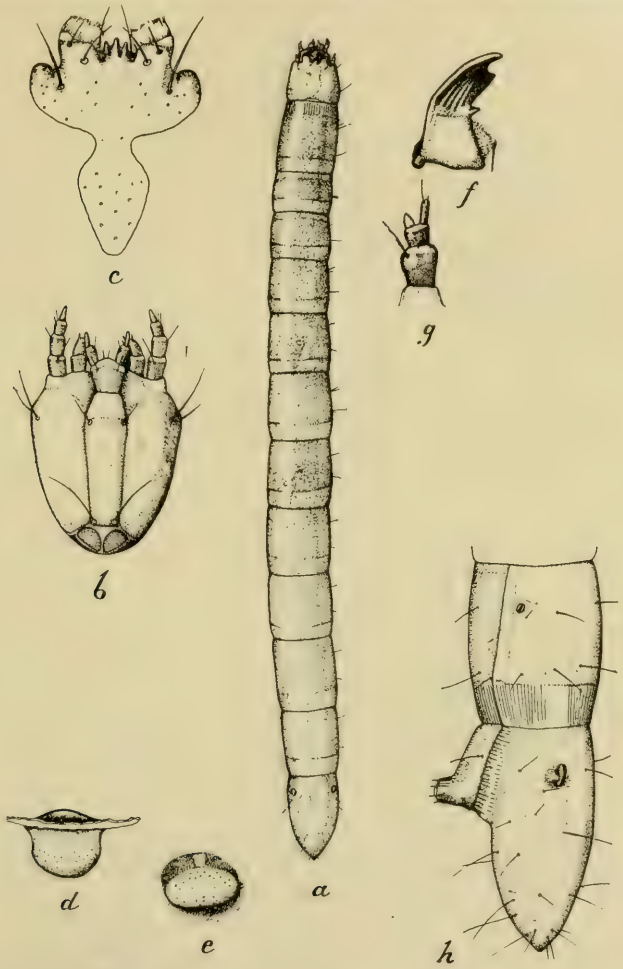


Fig. 7. *Agriotes mancus* Say. a, dorsal aspect of larva; b, ventral aspect of maxillae and labium; c, nasale and front; d, lateral aspect of invagination on 9th abdominal segment (dissected out); e, same from inside surface of integument; f, ventral aspect of right mandible; g, antenna; h, lateral aspect of 8th, 9th and 10th abdominal segments.

never smoothly rounded as in the Steatoderini, nor bearing a conspicuous terminal spine as in the Elaterini. The adults have the front strongly convex and lack the transverse carina, the mouthparts being directed downward.

The tribe Elaterini is characterized by the larvæ (Fig. 8) having the "nasale" unidentate; the ninth abdominal segment ending in a conspicuous spine; the transverse muscular impressions on the abdominal tergites very conspicuous.

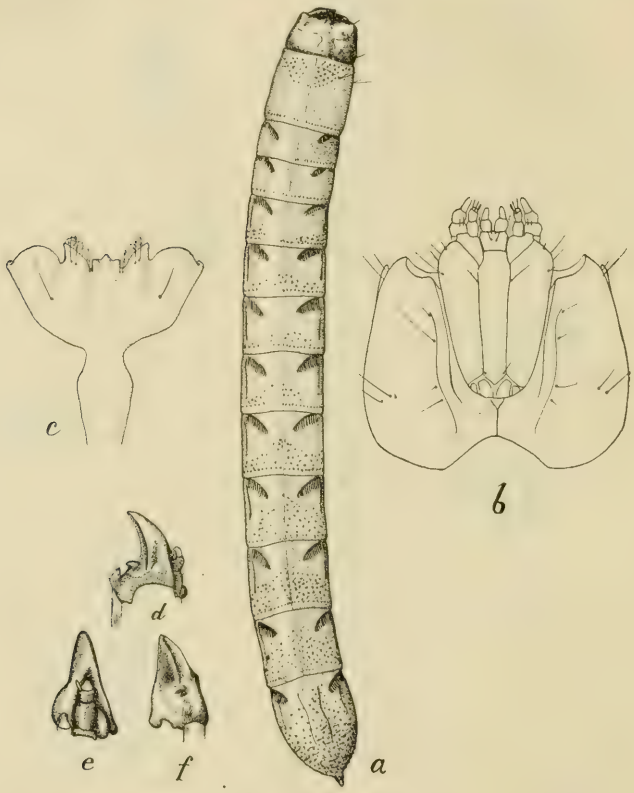


Fig. 8. *Ischiodontus oblitus* Cand. a, dorsal aspect of larva; b, ventral aspect of head; c, nasale and front; d, dorsal aspect of right mandible; e, lateral aspect of same; f, inner aspect of same.

The tribe Physorrhini is tentatively maintained to receive *Anchastus*. This tribe has been recognized by the leading authorities in this group and I have not had opportunity of examining positively determined larvæ. A larva tentatively determined as *Anchastus* bears strong resemblance to the larva of *Dolopius*.

The tribe Melanotini is characterized in the larval stage (Fig. 9) by having the ninth abdominal segment dorso-ventrally compressed caudad and ending in three lobes. The adults are easily recognized by the pectinate tarsal claws, being the *only tribe* in the subfamily in which this character is present.

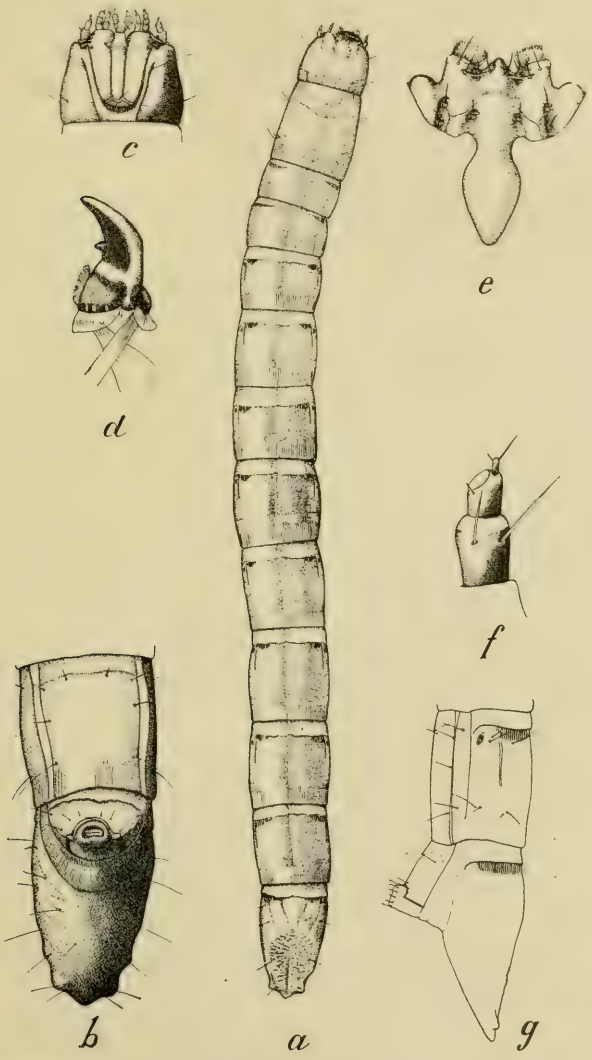


Fig. 9. *Melanotus sp.* a, dorsal aspect of larva; b, ventral aspect of 8th, 9th and 10th abdominal segments; c, ventral aspect of head; d, ventral aspect of left mandible; e, nasale and front; f, antenna; g, lateral aspect of 8th, 9th and 10th abdominal segments.

The tribe Steatoderini is subdivided into the two subtribes, Sericosomina to include the genus *Sericosomus*, and Steatoderina to include *Trichophorus*, *Orthostethus*, etc. The strongly convex head of the larva of *Sericosomus* and the broad penta-tuberculate mandibles with the single sense process (Böving 1910) on the second antennal segment easily distinguish members of this subtribe. The Steatoderina (Fig. 6) are the only Elateridæ bearing more than one sense process on the second antennal segment.

The tribe Agriotini is subdivided into the subtribes Agriotina and Adrastina. Agriotina (Fig. 7) is characterized by two deeply pigmented invaginations of the epidermis on the base of the ninth abdominal segment. These are not connected with the tracheal system and their function is problematical; they occur nowhere else in the Elateridæ as far as we know. The Adrastinæ agree with the Agriotina in the adult condition, but the larvæ are easily separated by the absence of the above mentioned invaginations and by the presence of transverse rows of setiferous tubercules on the ninth abdominal segment. *Betarmon* is hardly distinguishable in the larval stage from those species referred to our subtribe Adrastina. The adults have been referred to the tribe Pomachilini, which tribe is diagnosed by Candeze largely on habitus. They approach in one direction the Agriotina, in another the Elaterina and in another the Physorrhina. The tribe is probably a miscellaneous collection of genera which will eventually be referred to other tribes. *Ectinus*, the larva of which has been described by Henriksen, does not fall in either of these categories, but undoubtedly belongs in this tribe.

The tribe Elaterini is subdivided into the Elaterina and the Dicrepidina. In the former the transverse muscular impressions on the tergites of the abdomen are parallel with the anterior and posterior margins of these tergites, while in the Dicrepidina (Fig. 8) they are obliquely placed upon the tergites. The adults in the subtribe Elaterina never bear lobes on the tarsi, while in the Dicrepidina the second and third joints at least are lobed.

Cardiophorinæ.

The subfamily Cardiophorinæ includes the single tribe Cardiophorini and is characterized in the larval condition* by the membranous integument of the body, by the accessory digitate anal lobes, by the mandibles bearing teeth upon the exterior surface, and by the spiracles being placed upon retractile papillæ. The adults are easily distinguished by the truncate prosternal spine and the cordiform scutellum.

Addenda.

The placing of the following tribes in this classification is merely suggestive as no larvæ are known from any species contained therein and my conclusions are based entirely upon adult characters.

The first of these tribes, the Oxynopterini, is composed of four genera, and is characterized by the very excavate front, protuberant simple mandibles, simple tarsi, very elongate maxillary palpi, and the extremely broad metathoracic epimera. Hope separated this tribe from the other Elateridæ, erecting therefor a family, the Phyllophoridæ. The tribe seems to bear affinities with *Campsosternus* and *Tetralobus*.

The second, the Tetralobini, consists of the remarkable African Elaterids of the genus *Tetralobus*. Enormous insects measuring from 30-80 mm. in length, and characterized by the "plaque nasale" being as broad as long; mandibles dentate; antennæ strongly flabellate in male; and the tarsi lobed. They are probably closely related to the Oxynopterini.

The third unplaced tribe, the Eudactylini, which Candeze places with much reservation near the Dicrepidiini, is characterized by having the frontal carina well defined; the prosternal sutures fine and straight; tarsal joints short, very much dilated and often lamellate and the claws simple.

The fourth tribe, Crepidomini, lacks the frontal carina, the front flat or concave and usually acuminate; posterior coxæ gradually narrowed inwardly; and joints two to four of tarsi dilated. The tribe is confined to the Australian region and is allied to Ludiina and Lepturoidina.

* Figured in Bureau of Ent. Bull. n. s. 156, p. 8, Fig. 3b, 1915, and in greater detail in Proc. Ent. Soc. Wash. XVII, p. 179–185, Pl. 20, 21, 1915.

The fifth tribe, the Allotriini, lacks the frontal carina; the front more or less concave; and tarsal joints three and four lamellate at least on anterior tarsi. This tribe is closely allied to the next.

The sixth tribe, the Dimitini, also lacks frontal carina; front slightly declivious and flat; posterior coxæ incomplete exteriorly, that is to say, obliterated at the point nearest the metathoracic epimera. This is a very small tribe in which is placed the anomalous genus *Anthracopteryx* of Horn.

The seventh tribe, Hypodesini, is erected for the single genus *Hypodesis* of Central America and Mexico and distinguished by the convex front; large antennal fossæ; frontal carina obliterated above the point of insertion of labrum; super-antennal ridges oblique and short; mouth inferior; tarsal joints two, three and four lamellate; and tarsal claws simple. Intermediate between the Dimitini and the Cardiorhini.

The eighth, the Cardiorhini, is a very natural tribe and easily defined by the large bilobed labrum, which character alone suffices to distinguish these insects which are inhabitants of Tropical America. All the species belong to the genus *Cardiorhinus*. This tribe, with the three preceding, cannot even be placed hypothetically until the larvæ have been discovered.

The ninth, the Physodactylini, is a tribe erected by O. Schwarz in Genera Insectorum (1906) to receive five small genera from Africa and South America, all of which, with the exception of the type genus *Physodactylus* formerly referred to the Cebrionidæ, are quite recent.

That many discrepancies will be found in this arrangement of the Elateridæ is inevitable, for though I have examined larvæ of most of the holarctic genera, only a sparse representation of the world's *Elateridæ* are known. The holarctic fauna is extremely weak in Elaterid representatives as compared with the more tropical regions. The great centers of Elateridæ at the present time seem to be the Indo Malayan region and Tropical America. Larvæ of but one or two genera from these regions are known. About six thousand species of Elateridæ have been described for which five hundred and forty-eight genera have been erected. Therefore, we have seen representatives of less than one-tenth of the known genera in the family.

That this classification is on a much firmer basis than one depending entirely upon adult morphology, needs no confirmation. Many taxonomists have questioned the advisability of attempting to apply to the insects the axiom of the general zoologist, that ontogeny bears out phylogeny, that is to say, that the history of the race is borne out by recapitulation in the history of the individual. They contend that, though undoubtedly the evolution of the race leaves its impressions upon the successive stages in the ontogeny of the extant representative of that race, the insect larva is so actively associated with its environment that adaptive variations will entirely obliterate these phyletic inheritances. Though this is undoubtedly true in a certain degree, and must be considered when reviewing larval characters, it has been overstated, at least in the Elateridæ. Representatives of nearly all the tribes are found in a variety of habitats much more diverse than the habitats of many families of mammals, yet they retain the phyletic characters so as to leave no doubt whatever as to their relationship. For example, larvæ of the genus *Melanotus* are found in rotten logs, in cultivated fields, under stones, in forest moss, and in mud. No one would question the relationship of the various species of *Melanotus*, and their larvæ, even under these extremely different habitats, are almost inseparable. Larvæ of the genus *Elater* are found in rotten logs, in the stems of mushrooms, under stones, and under lichens on exposed boulders, yet an *Elater* larva can be recognized at a glance, and no important phyletic characters have been obscured by adaptive modifications. I believe it more logical to accept ontogenic evidence, with reasonable reservation, than to blindly follow adult comparative morphology, without taking into consideration the enormous possibility of error on account of convergent variation due to the fact that the adult Elaterids are much less diverse in habits than are their larvæ. As far as we know their habits, they all frequent flowers and leaves and are exclusively phytophagous, while the larvæ live in practically all habitats, except the truly aquatic, and are both carnivorous and phytophagous.

The Schematic tree (Fig. 10) is arranged to express my concept of the phylogeny of the Elateridæ, of which the larvæ are now known. The vertical elevation of the origin of the

various branches is but very roughly indicative of a relative time displacement. The lateral arrangement of the genera is intended to indicate the superficial relationship of the present day genera. The sub-families Pyrophorinæ and Elaterinæ evidently branched off in the quite remote past.

The paleontological record has recently been carefully studied by Professor Wickham,* who has presented a most excellent review of our knowledge of the fossils of these insects.

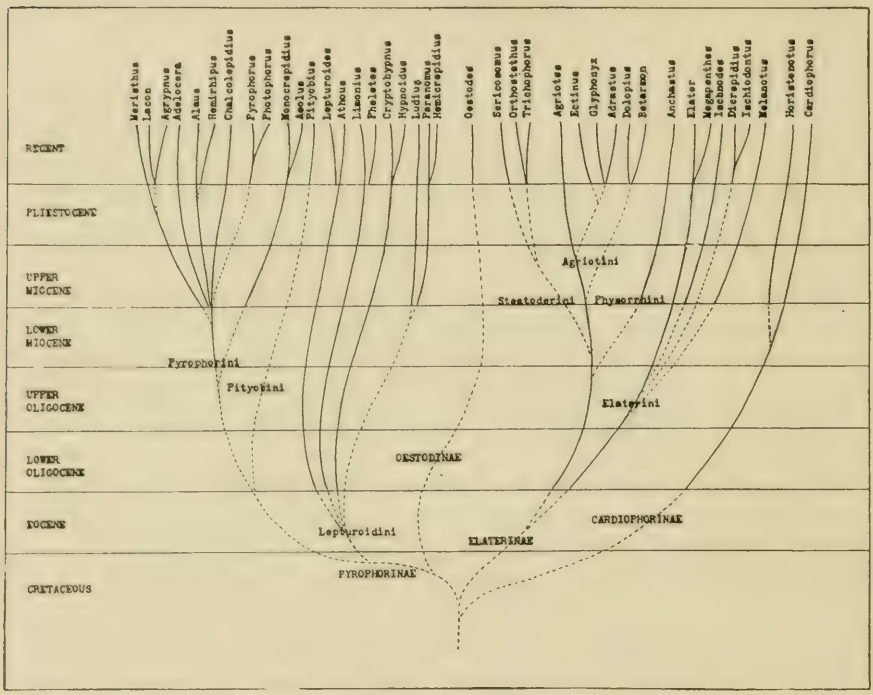


Fig. 10. Schematic Phyletic Arrangement of the Elateridae. Solid lines indicate known geologic time that genera were extent. Dotted lines are hypothetical.

Fossils having a decided Elaterid habitus are found at the base of the Mesozoic era in the Triassic rocks, these specimens, recorded by Handlirsch, bear no character, however, which can definitely place them in this family. Similar fossils are also found in the Liassic. The Jurassic chalks bear fossil insects which are decidedly elateriform, but the placing of

* Bull. Mus. Comp. Zool. LX, No. 12, p. 493–527, 1916.

such in our present genus *Elater* is hardly justified. It is probably safe to place the original Elaterid stem in the upper Jurassic. The palontological record is blank from the time of these earlier fossils until the early Tertiary. The baltic ambers of the Lower Oligocene contain Elateridæ so well differentiated as to be referable to extant genera. Eucnemidæ are very numerous, as would naturally be expected in Amber faunas. The Cardiophorinæ had already split off from the parent stock, probably in the Upper Cretaceous. The Pyrophorinæ were already differentiated into their main tribes, but what seems most remarkable is that the Lepturoidini and not the more conspicuous Pyrophorini are represented. In fact, the Pyrophorini are not recorded until the Upper Miocene where they abound in both the Oeningen beds in Europe and in our own Florissant of Colorado. This seems to indicate that our tribe Pyrophorini left the Pyrophorinæ stem at a much later period than the tribe Lepturoidini. The great gap in the record covers the period in which the greatest Elaterid diversification took place, that is in the Cretaceous and lower Eocene.

Family ELATERIDAE.

Italicized tribes and sub-tribes are tentatively placed, as larvae of species have never been described.

Subfamily Pyrophorinae
1. Tribe Pyrophorini
 - Sub tribe Agrypnina
 - Sub tribe Hemirhipina
 - Sub tribe Chalcolepidina
 - Sub tribe Pyrophorina
 - Sub tribe Monocrepidina

 Tribe *Oxynopterini*
 Tribe *Tetralobini*
2. Tribe Pityobini
 - Sub tribe Pityobina

3. Tribe Lepturoidini
 - Sub tribe Athouina
 - Sub tribe Lepturoidina
 - Sub tribe Ludiina

 Tribe *Crepidomini*
4. Tribe Oestodini
 - Sub tribe Oestodina

Subfamily Elaterinae
1. Tribe Steatoderini
 - Sub tribe Sericosonina
 - Sub tribe Steatoderina

2. Tribe Agriotini
 - Sub tribe Agriotina
 - Sub tribe Adrastina

3. Tribe Elaterini
 - Sub tribe Elaterina
 - Sub tribe Dicrepidina

 Tribe *Eudactylini*
4. Tribe Physorrhini
 - Sub tribe Physorrhina

5. Tribe Melanotini
 - Sub tribe Melanotina

Subfamily Cardiopherinae
Tribe Cardiophorini
- Sub tribe Cardiopherina

Subfamily Physodactylinae

Tribes not yet located:
Tribe *Allotriini*
Tribe *Dimitini*
Tribe *Hypodesini*
Tribe *Cardiorhini*

TAXONOMIC VALUE OF ANTENNAL SEGMENTS OF CERTAIN COCCIDAE.

A. H. Hollinger, Missouri Agricultural Experiment Station.

During the past two seasons the writer has been making special investigation of the *Coccidæ* of Missouri, and during that time many interesting forms, *Diaspinæ* as well as others, have been found, including several new and rare species. The *Diaspinæ*, while presenting certain problems in themselves,are not nearly so perplexing as are the mealy bugs, including *Phenacoccus*, *Pseudococcus*, and *Trionymus*, the *Eriococcids*, the *Lecania*, and other genera of the *Coccinæ*. While it is a comparatively simple matter to identify armored scale insects by means of the pygidia, it has been an almost impossible task for the average entomologist to separate the different species of the so-called soft scales, due to the fact that there have been very few constant, tangible characters for comparison in this broad group. Some writers have made a study of the fringe of setæ and accompanying gland pores surrounding the anal openings in certain of the mealy bugs (5). Others have studied the cerarii (5) which are the grouped conical spines and accompanying gland pores along the sides of certain of the mealy bugs. A few have elaborated on the structures of the anal plates of the *Lecania* (2). Many others have attempted to characterize species of *Coccidæ* by establishing a formula for the lengths of the antennal segments. While each of these may be of some value in strict systematic work, the practicability of using any one of these for easy identification of species is slight, at best. What is needed in coccidology is to put the study of soft scales upon a practical working basis, and so it was with this aim in view that the writer has given much of his time to close inspection and careful comparative study of the several genera of the native soft scale insects.

Cockerell's note (4), in which mention was made concerning the value of antennal segments in the determination of coccid species when antennal curves were plotted, led the writer to investigate this method.

There has been much debate among entomologists as to whether or not antennæ in coccids are of any taxonomic value.

Marlatt (1) stated that he had the gravest doubts as to the value of the measurements of antennal segments in the determination of species, because the antennal formulæ varied so greatly even in the same individual. Pergande (1), Smith (3), and undoubtedly many others have been misled into thinking similarly because of the apparent discrepancies which arise in the antennal formulæ of any particular species, but which, if carefully worked out by the curve method, would present a definite working basis for that species. Quoting Cockerell (4): "It does not follow, as some uncritically assume, that antennal measurements are useless" just because the antennal formulæ are so variable.

Due to the fact that no published directions for making the curves were known to the writer at the time this investigation was started, he proceeded along lines of his own initiative and used a system for the graphic representation of the antennal segments which not only shows the general trend of the individual curves, but also shows the mean curve for all the measurements of normal antennæ in any particular species.

Using millimeter graph paper, the writer laid off in succession, working downward on the vertical axis or axis of ordinates, distances of ten millimeters. Each unit of ten millimeters was let represent one antennal segment. It is needless to mention that this unit was an arbitrary one, for the writer might just as well, except for lack of space, have taken larger units. On the horizontal axis, or axis of abscissis, the lengths of the successive antennal segments were plotted, one millimeter being used to represent a length of one micron. The writer could have taken a different unit, but for the sake of simplicity and compactness, the above-mentioned one was chosen. These units have been used in all the accompanying curves, and consequently they are uniform and comparative. Connecting the points in succession along the direction of the vertical axis produced the graphic figures. In all cases under observation, these curves are distinctive and characteristic of each species the writer has studied, as a comparison of the figures will show. All figures have been photographically reduced one-half.

After having followed this system for producing the antennal curves, the writer learned, through the United States Bureau of Entomology, that Brain (6) had published a few years previously the graphic representations of the antennal segments

of certain South African species of *Coccidæ*. Reference to this paper, however, led the writer to adopt the plan of the curves as originally used, and not to adopt the method used by Brain. To the writer, as well as others who have inspected this paper, the curves shown herein are to be preferred over those of Brain's, for they give the general trend of the individual curves, the general trend of the curves of the species as a whole, and the mean curve of the species.

According to Cockerell (4): "the curves will of course vary, hardly any two antennæ being exactly alike; but except for abnormalities (pathological specimens), nearly every species gives quite different curves, while two species, very different in other respects, will give nearly the same curve. Some of the widely distributed species give curves almost too variable to be of much service, but in these cases, it is possible that the material contains more than one thing."

Brain (6) summarizes the taxonomic value of antennal segments of *Coccidæ* as follows: "The lengths of the antennal segments are of great importance in the determination of species if the measurements are accurately made from stained specimens and properly tabulated." "The most useful arrangement of antennal data seems to be arrived at by giving the range of variation in the measurements of the different segments, with the addition, perhaps, of the mode of each. After working over a large series of slides, one is impressed with the characteristic appearance of the different antennæ. But this difference is difficult to express. The nearest approach is obtained by a" graphic representation of the lengths of the antennal segments, "and this supplies a most useful aid for the preliminary location of an insect from slide specimens." "Similarity of antennal curves, while indicating similarity of antennal formulæ, does not of necessity indicate identity of species, but it does give a clue to work upon and possibly at times indicates relationships."

The writer is led to believe that these graphs are one of the main characterizing taxonomic features, and this view has been strengthened and sustained by several incidents and observations, among which the following will clearly illustrate their importance.

Several lots of *Pseudococcids* were collected by the writer, one of these in early spring of 1916 under the rough bark of

wild grape, about ten miles south of Columbia, Missouri, and the others in and around Columbia, Missouri, during midsummer upon Lactuca canadensis, L. sagetifolia, Geum canadense and Solidago stricta. Careful mounting and examination of the materials on the above mentioned annuals and on the perennial Solidago stricta readily disclosed the fact that these four lots belonged to the same species, *Pseudococcus shaferi* species novo, and the antennal graphs further substantiated this result beyond a doubt. The material from wild grape was also mounted, there being one adult female and several nymphs. The antennal graph, as first made, was misleading, due to the fact that the antennal measurements of the adult and of the young were plotted together, thus hiding the true antennal graph of the adult. So this coccid on wild grape was at first referred by the writer in his manuscript to a new species. It was only after replotting the antennal measurements of the adult's segments that the similarity to the graph of *Pseudococcus shaferi* species novo was observed. Careful comparisons of the descriptions also showed identical details, such as the alveolated posterior coxæ, the size of the leg segments, the anal ring and anal lobe setæ, the conical spines in the cerarii, the spiracles, the obscureness of the cerarii anterior to those on the anal lobes, etc., so that undoubtedly the coccid from wild grape is also *Pseudococcus shaferi* species novo. The reason for the apparent difference in food habit is that this coccid, feeding upon annuals and perennials throughout the growing season, forsakes such situations late in the fall and ascends to places which will insure dryness and protection throughout the winter and early spring and here forms its ovisac, the spring brood descending to feed upon the preferred food plants, which are either annual or perennial. Such procedure has been observed in the case of *Trionymus americanus* (Ckll.) which left its food plants—several kinds of grasses—and ascended the trunks of different species of trees late in the fall, and upon which their ovisacs were formed.

Other similar instances might also be cited, but the writer feels sure that the value of the graphic representations of the lengths of antennal segments has been clearly shown in the above cited case.

It will be noticed in the discussion of the accompanying graphs that the writer gives the antennal formula of the mean

curve of each species. While these formulæ are not considered to be of primary importance, they at least remain fairly constant for each species where a large number of measurements have been plotted. Where it was possible to use only a few measurements, the formulæ of the mean curves of those species would probably vary to a slight extent if more measurements had been used. In all cases as many measurements as possible were plotted, ranging from only two or three to over sixty.

The writer does not merely characterize the various new species of coccids upon the basis of the antennal segments alone, but in all cases they formed the working basis for their identifications. One thing worthy of note is that all the species of *Pseudococcus* known to occur in Missouri have the last antennal segment the longest, as is shown by the antennal formulæ of the mean curves of those species, or by the mean curves themselves. On the other hand, most of the remaining species do not have the distal segment the longest.

The new species of scale insects mentioned in this paper are fully described, figured, and discussed by the writer in his manuscript on the Coccidæ of Missouri. They will later be published in a Missouri Agricultural Experiment Station bulletin, so that the exact distribution, food plants, and further distinguishing characters of these new species will be forthcoming in the near future.

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EXPLANATION OF PLATES

Plate XIX

Figure 1 represents the antennal curves of a new species of *Coccinæ*, *Exæretopus boonei* species novo which has two segments to the tarsi. The writer places it in the genus *Exæretopus* (which may be the same thing as *Luzulaspis*) because of this peculiarity. It is the only one of this genus found in Missouri. Some of the other distinguishing characters are the whip-tail gland ducts, the marginal fringe of body setae or spines, the large Sclerotinia-shaped spiracles, the anal plates, the anal ring, etc. Ulmus americana is one of its hosts. The antennal formula for the mean curve is 4831(56)72.

Figure 2 is the antennal graph of *Phenacoccus regnillohi* species novo. This species is further characterized by the stout, white, waxy *Orthezia*-like lamellae, by the cerarical spines, by the deep maroon color of the body, by the spiracles, etc. Ostrya virginiana is the only known host. The antennal formula for the mean curve is 93251(678)4.

Figure 3 is the graph of *Phenacoccus celtisifoliæ* species novo, found feeding upon the leaves of Celtis occidentalis. Although this graph bears a slight resemblance to that of Figure 5, it may be readily separated from it by the presence of simple body glands, by the cerarii, by the absence of long, glassy, hair-like filaments, by the shape of the body and by the canary-yellow color of the body. The antennal formula for the mean curve is 239154678.

Figure 4 represents the antennal curves of *Phenacoccus grandicarpos* species novo. It is also characterized by the large size of the adult female, being the largest species of this genus the writer has seen; by the cerarii, and by the tea-green color which results when boiled in 10% KOH. The antennal formula for the mean curve is 92178(35)64.

Figure 5 is of *Phenacoccus pettiti* species novo, the most common species of this genus in Missouri. This species is further distinguished by bearing many long, waxy, glassy, hair-like filaments on the dorsum, by the grayish color of the body, by the cerarii, and by the peculiar body glands. The antennal formula for the mean curve of this species is 329541678.

Figure 6 is the curve of *Coccus hesperidum* Linn. The antennal formula for the mean curve is 3472165.

Figure 7 is the graph of *Lecanium nigrofasciatum* Perg. The antennal formula for the mean curve is 362154. The over-wintering stage of this species was used for study.

Figure 8 shows how the antennal segments of *Saissetia oleæ* (Bern.) appear when plotted. The antennal formula for the mean curve of this species is 32(18)4567.

Plate XX

Figure 9 is the graph of *Eriococcus borealis* Ckll. which the writer has found on Celtis occidentalis and Aesculus glabra. The first antennal segments are not plotted, because of the difficulty of obtaining exact measurements of the basal joints. The antennal formula for the mean curve of the adults is 342765. Figure 11 is the graph of the antennae of the nymphs of this species. The antennal formula for the mean curve of the nymphs is 732465.

Figure 10 shows the curves of *Coccus elongatus* (Sign.). The antennal formula for the mean curve of this species is 3218(45)67.

Figure 11. The legend for this is embodied in the discussion of Figure 9.

Figure 12 represents the curves of the common greenhouse mealy bug, *Pseudococcus citri* (Risso). The antennal formula for the mean curve is 82317654.

Figure 13 is the graph of *Lecaniodiaspis pruinosa* Hunter. It is a common species in this part of the country. The antennal formula for the mean curve is 435127689. The immature females with eight-segmented antennae should not be confused with the adult females, although they appear similar externally.

FIGURE 14 is the curve of *Eriococcus missourii* species novo. It is further characterized by the peculiar striped, dermal, color markings of the females. The antennal formula for the mean curve is 437256. The first segment is not considered, because of the difficulty in measuring its length.

FIGURE 15 is the graph of a variation of *Eriococcus missourii* species novo. It apparently is a six segmented form, the third joint being the longest and about equal to segments Nos. 3 and 4 of the seven segmented form. The antennal formula for the mean curve of the six-segmented form is 36254. The first antennal segments are not plotted.

FIGURE 16 is the curve of *Pseudococcus nipæ* (Mask.) a very pretty, sedentary mealy bug. The antennal formula for the mean curve of this species is 72(13)645.

FIGURE 17 is the graph of *Gossyparia spuria* (Modeer) collected on elm in Michigan. It is not indigenous to Missouri so far as the writer knows. The antennal formula for the mean curve of this species is 342756.

FIGURE 18 is the graph of *Lecanium* spp. non det. found in large numbers upon ash. The antennal formula for the mean curve is 3471265.

FIGURE 19 shows the curves of another *Lecanium*, *L.* spp. non det. found abundantly upon elm. The antennal formula for the mean curve is 3472165.

PLATE XXI

FIGURE 20 represents the antennal segments of *Pseudococcus shaferi* species novo, found upon annuals and perennials, and also hibernating under the rough, exfoliating bark of wild grape. This particular curve was formerly thought, by the writer, to belong to a distinct species, but subsequent examination and comparison of the material with that which was used to produce the curves in the next figure, showed conclusively that it was the same species. No mean curve is shown in this figure, because that of Figure 21 applies to this, as well.

FIGURE 21 is the graph of *Pseudococcus shaferi* species novo. It is further characterized by the cerarii, etc. The antennal formula for the mean curve of the adults of this species is 82137(56)4. Figure 23 is the graph of the nymphs' antennae. The antennal formula for the mean curve of the antennae of the nymphs is 632154.

FIGURE 22 is the graph of the antennal segments of *Pseudococcus jessica* Hollinger. Descriptions and figures of this species are given in the Canadian Entomologist for December, 1916, and for January, 1917. The antennal formula for the mean curve of this species is 8(12)37564.

FIGURE 23 (See legend as given under Figure 21).

FIGURE 24 is the graph of *Pseudococcus morrisonii* species novo, collected from white hickory. It is further characterized by the cerarii. The antennal formula for the mean curve of this species is 81237654.

FIGURE 25 is the graph of *Pseudococcus mcdanieli* species novo. This species is further characterized by forming an ovisac of white, fluffy filaments which often completely cover the body of the adult female; also by the seven segmented antennae, by the cerarii, etc. Ragweed, Ambrosia trifida, seems to be its most preferred food plant. The antennal formula for the mean curve is 713(24)65.

FIGURE 26 is graph of the nymphal stage of *Trionymus americanus* (Ckll.). This species is a grass feeding coccid. The antennal formula for the mean curve of the nymphal antennae is 7126435.

FIGURE 27 is the graph of the adults' antennae of the species, *Trionymus americanus* (Ckll.). This species is further characterized by having cerarical spines only on the ultimate and penultimate segments. The antennal formula for the mean curve of the adults' antennal measurements is 81273564.

Plate XXII

Figure 28 is the graph of *Pseudococcus pseudonipæ* (Ckll.) collected from palms. The antennal formula for the mean curve of this species is 71246(35).

Figure 29 is the graph of the clover-root mealy bug, *Pseudococcus trifolii* (Forbes). It is further characterized by the cerarii, which occur only on the ultimate segment of the winter female. The antennal formula for the mean curve of this species is 7126435.

Figure 30 is the curve of the measurements of the antennal segments of *Lecanium* spp. non det. collected only from perennials. The antennal formula for the mean curve of this species is 3427165.

Figure 31 is the graph of *Pseudococcus omniverae* species novo, which is very common and omniverous in its feeding habits. It is further characterized by the cerarii, dermal characters, etc. The antennal formula for the mean curve of this species is 83215764.

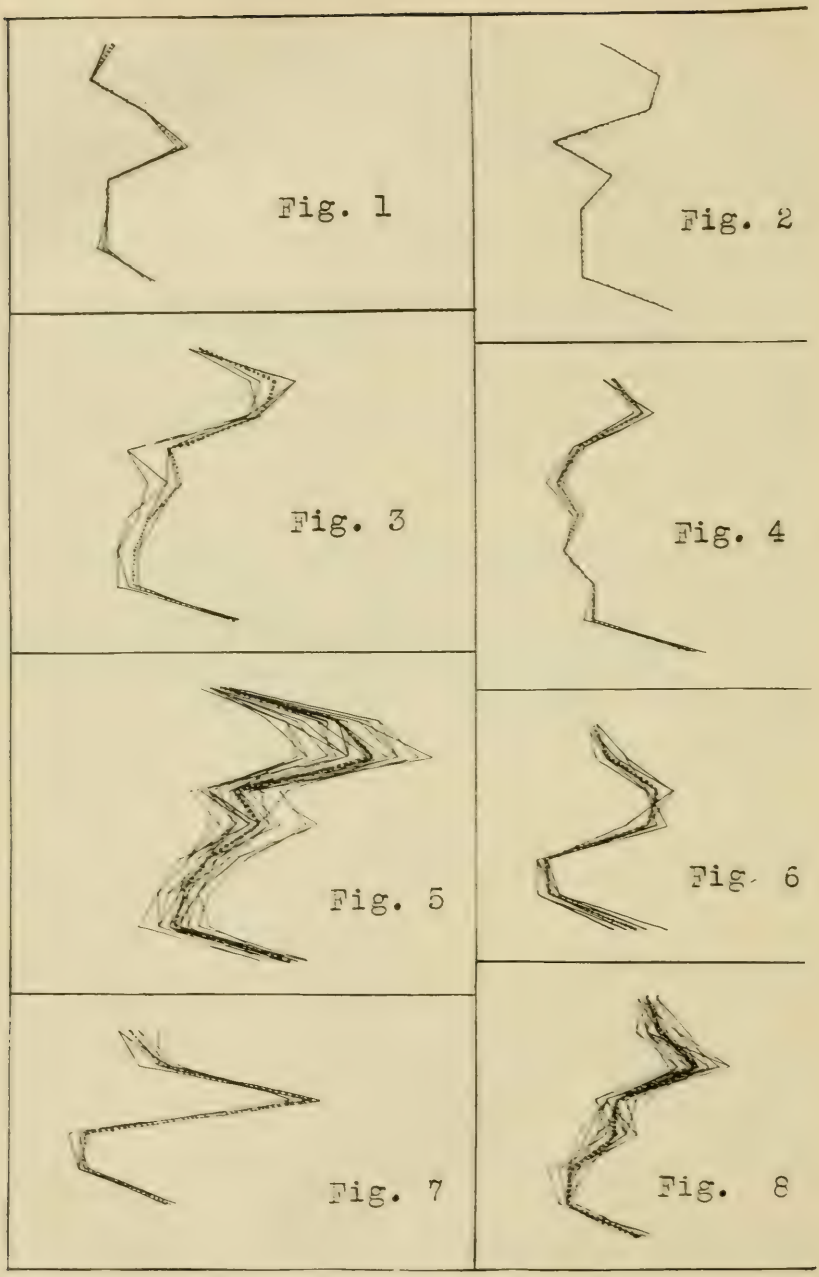
Figure 32 represents the curves of *Pulvinaria amygdali* Ckll., found abundantly upon the leaves of gooseberry. The antennal formula for the mean curve is 32145867.

Figure 33 is the graph of a seven segmented species of coccid found on sycamore, *Lecanium* spp. non det. The antennal formula for the mean curve is 732(14)65.

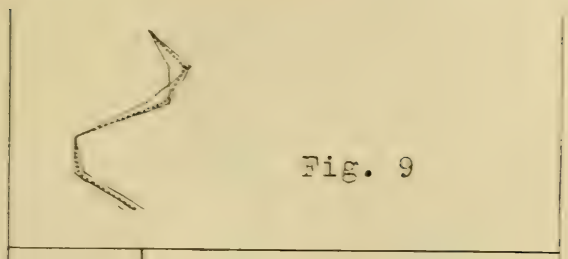
Figure 34 represents the golden rod *Orthezia*, *O. solidaginis* Sanders, a very common species around Columbia, Missouri. The antennal formula for the mean curve is 381546(27).

Figure 35 shows the curves of *Pseudococcus longispinus* (Targ.). The antennal formula for the mean curve of this species is 82315467.

Figure 36 is the graph of *Pulvinaria vitis* (Linn.) the cottony maple scale. The antennal formula for the mean curve of this species is 342185(67).



1. *H. Hollinger.*


Fig. 9

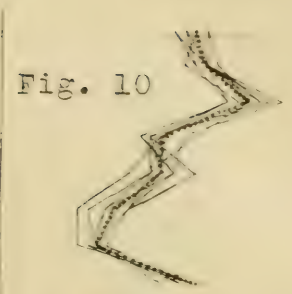
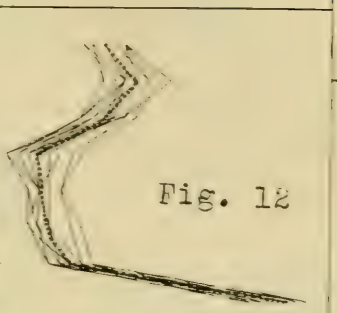
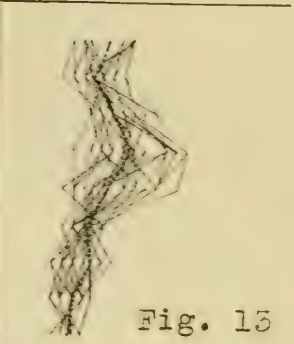
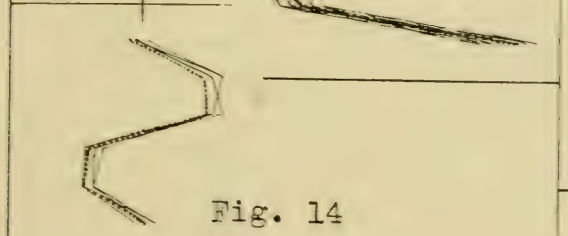
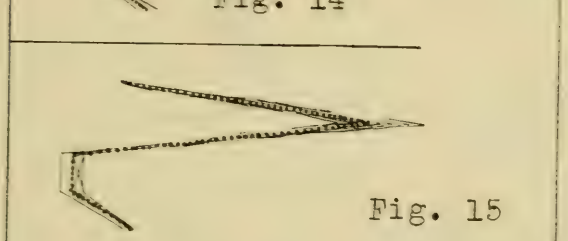

Fig. 10

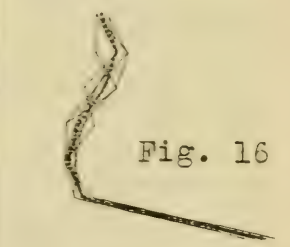

Fig. 11


Fig. 12


Fig. 13


Fig. 14


Fig. 15


Fig. 16

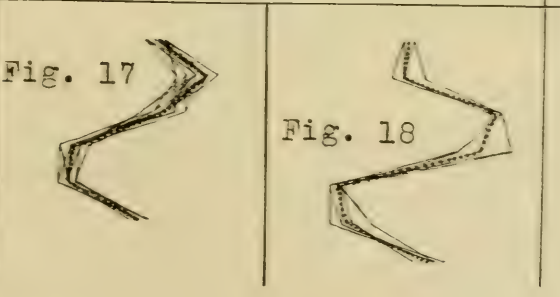
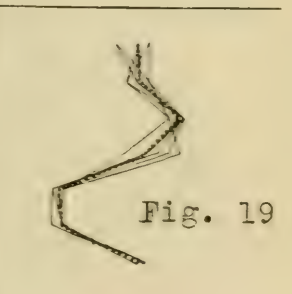
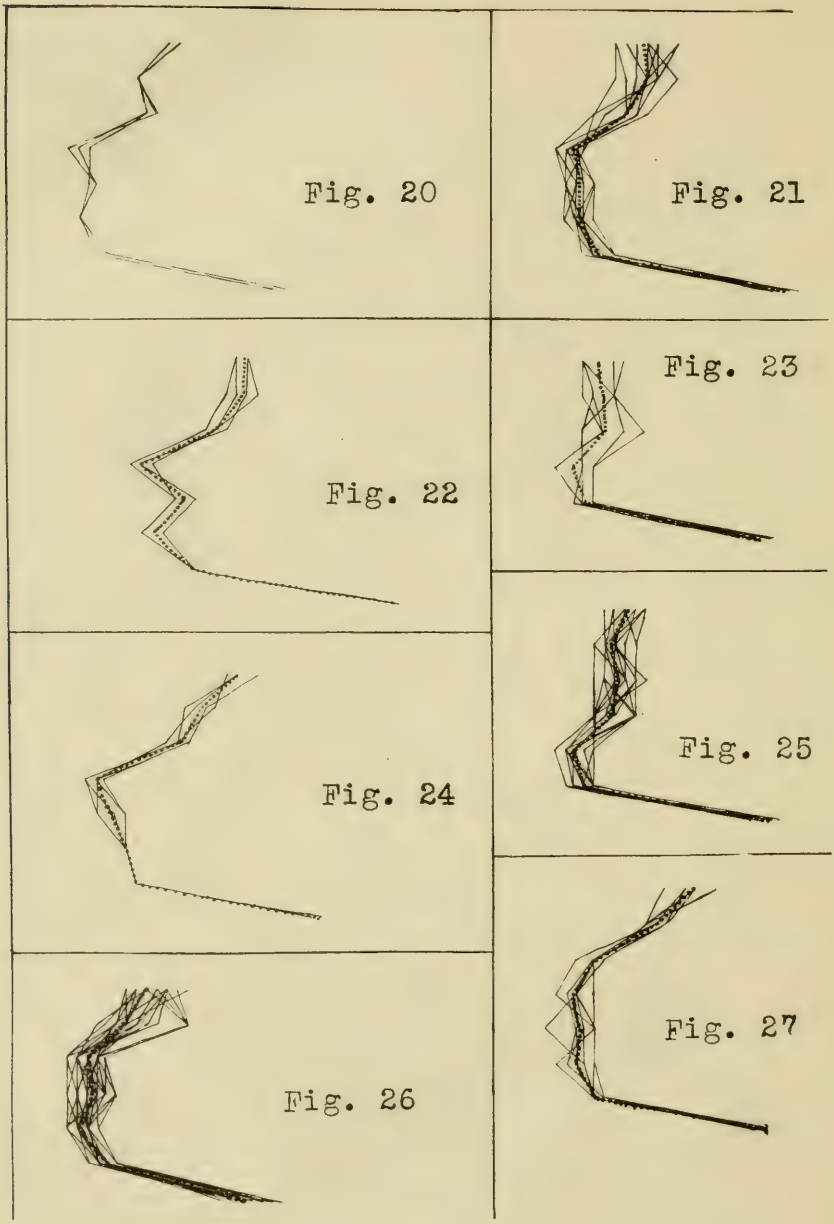

Fig. 17

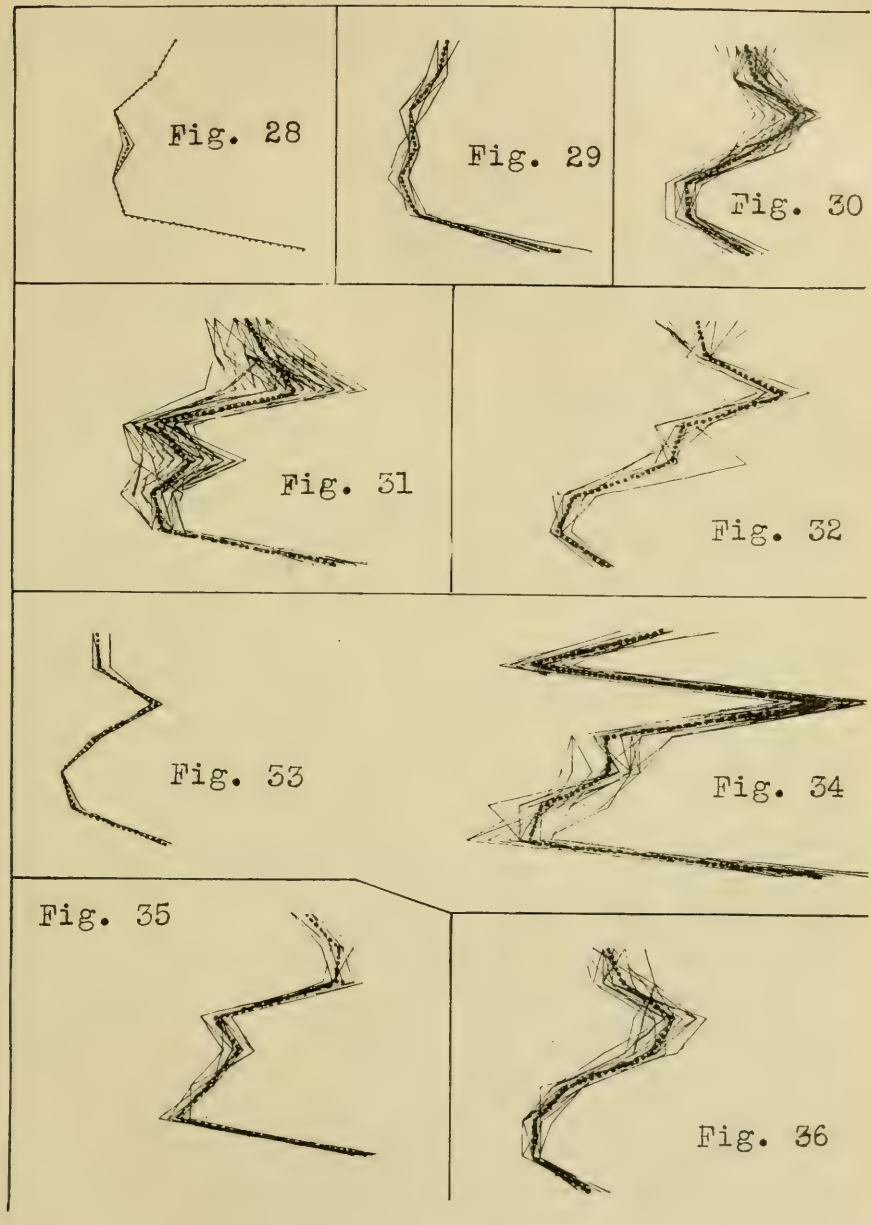
Fig. 18


Fig. 19

A. H. Hollinger.



A. H. Hollinger.



A. H. Hollinger.

NOTES ON BOMBIDAE, AND ON THE LIFE HISTORY OF BOMBUS AURICOMUS ROBT.

THEODORE H. FRISON, Champaign, Illinois.

Up to the present, little work has been done on the life-history of our American *Bombidæ*. Mr. F. W. L. Sladen, in his admirable book, "The Humble-bee," has given us, however, the principal facts in the life-history of the common English *Bombidæ*, besides many other observations of importance and interest.

There are several reasons to account for the dearth of literature on the subject of the life-history of bumblebees. Unlike the honey bee, all the individuals of *Bombus*, with the exception of the new queens, die in fall. The new queens hibernate throughout the winter in various situations, and issue forth in spring, to start new colonies. In order to obtain a good, clear, and accurate account of the life-history of *Bombus*, constant observations must be made, from a very early date in the history of the colony.

In spring, the nests of *Bombus* are less likely to be found than later in the season. This is mainly due to the fact that the nests are then smaller, and contain fewer bumblebees to attract attention. Many of the nests of *Bombus*, mentioned in the literature, were found and opened in late summer or fall. The opening of a nest in the late summer or fall permits only of observations regarding the size of the colony, the number of bumblebees of each caste present, the number of eggs, larvæ, pupæ, arrangement of the comb, and various other miscellaneous notes. The attempt to transfer a nest in spring or early summer from the field to an observation box, and to carry on a series of observations, is very apt to cause the queen to abandon her nest. In April, 1910, I found many *Bombus* queens of various species, occupying old, deserted nests of field mice. These nests were in an old pasture on the surface of the ground. No adults had as yet emerged in any of the nests examined, the nests containing eggs or small larvæ, or both. Not one of these nests was transferred to an observation box with success; the queen either deserting the nest after several days, or if confined,

dying within a short time. During the spring of 1916, however, I managed to transfer successfully young colonies of *B. pennsylvanicus* DeGeer from their original quarters to observation boxes.

Attracting Queens to Artificial Nests.

Mr. F. W. L. Sladen found that by burying various types of domiciles in the ground in spring, he could attract *Bombus* queens and get them to nest. This enabled Sladen to get the colony at its very inception, and then by carefully removing the nest to an especially constructed bumblebee-house, the life-history could be successfully studied.

In the spring of 1915, I tried Sladen's method, using a domicile of my own design, and had the satisfaction of finding that one of my domiciles had been selected by a queen of *B. pennsylvanicus*. This queen, however, deserted the domicile because of excessive moisture. In April, 1916, I tried the experiment again, using a slightly different type of domicile, and was more successful than before.

In one domicile, which I had placed in a clay embankment, beside a railway track, and near open woods, a queen of *Bombus auricomus* Robt. started her nest. This domicile was placed in the ground on April 15, 1916, and was observed to be occupied on June 24, 1916. On the last-mentioned date, the nest was removed to an especially constructed observation box for bumblebee nests. This nest contained, when first found, the following: nine eggs, three large larvæ, five pupæ in various phases of development, one medium-sized worker, and the mother queen. Judging from the silvery, moist, and matted appearance of the worker, the worker had only recently emerged. In addition the nest contained one empty cocoon in the center of the group of cells, and a wax-pollen honey-pot. This honey-pot was separate from the remainder of the comb and was near the entrance of the nest. The queen, at this period in the history of the colony, still retained her glossy, slick, well-kept appearance of youth.

Egg-Laying Habits of *B. auricomus*.

One of the striking habits of *B. auricomus*, noticeable at the very outset of study, was that each egg was deposited in a separate egg cell. Such a characteristic has, to my knowledge, not

heretofore been found in any species of *Bombus*. During the time that this colony of *B. auricomus* was under my observation, no eggs laid by the queen were ever deposited in batches in a single wax-pollen mass, but always in separate cells. These egg cells, or chambers, were constructed by the queen usually about twelve hours before the eggs were laid. Occasionally an egg cell was constructed, and then allowed to stand empty for several days. The queen usually laid several eggs within a period of twenty-four hours; occasionally laying more, and sometimes not laying any eggs for several days at a time. Eggs laid within a short interval of each other, were deposited in egg cells adjoining one another; thus giving the adjacent egg cells somewhat the appearance of an egg mass, but always spread out over a larger area on the surface of the comb. The place selected by the queen on which to construct her egg cells, was usually on one side, near the top of a newly spun cocoon; or in the depressed area formed between the tops of adjoining cocoons.

I have never seen a worker of *B. auricomus* making an egg cell, though there seems to be no reason why an egg-laying worker should not do so. On July 28, the mother queen was lost from the nest; her loss being traceable to the fact that she fell from the ledge at the entrance of her nest, and as her wings were clipped, could not return. For several days after the old queen disappeared from the nest, the workers were abnormally irritable, frequently biting one another, or chasing one another over the comb. On July 31, several new, empty, separate egg cells were found; and on August 2, these cells contained eggs. These last-mentioned eggs and egg cells were undoubtedly made by egg-laying workers. The stimulus that leads to the construction of an egg cell, is probably the same in both workers and queen. This stimulus is possibly due to the presence of a ripe egg in the ovaries.

On June 26, the queen laid five eggs, which is the largest number of eggs she ever laid during a single day of which I have any record. Before the queen was lost, and after the nest was transferred, she had laid thirty-seven eggs. To this total of thirty-seven eggs must be added the number of eggs, larvæ, pupæ and adults in the nest at the time the nest was taken, thus making forty-five eggs in all. The eggs are three and one-

half millimeters long and one millimeter wide; are white, sub-crescentic, tapering somewhat at one end, with both ends rounded.

General Notes on *B. auricomus*.

Within a short time after the nest had been transferred to the observation box, the queen and worker seemed to be entirely at ease, and performed their duties as if nothing had happened. Food, consisting of a mixture of honey and water, was supplied to the queen and worker in small tin containers for several days after the transference of the nest. Feeding was necessary because the bumblebees were not allowed their freedom for several days after transference.

During the early stages of the history of the colony, the queen and solitary worker applied themselves industriously to their work. Just how the queen laid her first eggs, and cared for her first brood, I was unable to observe, as the nest was not taken in time; but the procedure probably does not differ essentially from that followed at a later date. The queen and her worker devoted much of their time to the tasks of feeding the larvæ, and of brooding over the comb, especially that part containing the egg cells. While brooding over the comb, the queen frequently and intermittently made a loud purring noise, accompanied by a sharp twitching of the wings. This purring of the queen could frequently be heard almost sixteen feet from the nest. On June 28, two more workers, both somewhat larger than the first worker, emerged within twelve hours of each other. On July 7, there were eight workers in the nest, all of which had emerged about a day or so apart. Such an irregularity in the rate of emergence of the first few workers, tends to support my belief that the first eggs laid by the queen of this species are laid separately, and at different intervals; instead of several eggs being laid at the same time in one batch.

In order to examine the eggs and young larvæ, the queen and workers were often removed from the nest, and then later returned. If one tried to open a cell while the queen or workers were around, the bumblebees would attack the forceps used in the operation, and bite them with their mandibles. Again, the bumblebees would cover over the cells, almost as fast as I could pry off the coverings without danger to the cell contents.

Every morning for about two weeks, I found that it was necessary, in order to see the contents of the nest, to remove a covering of grass, compactly held together by means of a mixture of pollen and wax. This grass covering, or roof, made by the bees naturally serves to keep light from entering the nest, for general protection, and as an aid in keeping the temperature within the nest constant.

The Egg Stage of *B. auricomus*.

From this colony of *B. auricomus*, drones, workers, and queens were reared, under observation, from the egg to the adult stage. My notes show that the number of days in each stage of development, in all three castes, is subject to variation. Nutrition and temperature undoubtedly play a very important part in the lengthening or shortening of the various stages. The egg period varied from four to six days. No special, consistent variation in the duration of the egg stage of the three castes was noticeable, but additional data may prove the contrary. Mr. F. W. L. Sladen found that, as in the case of the honeybee, eggs laid by workers produced drones. I was unable to find out what finally happened to the worker eggs in this nest, but I am sure that if the eggs ever hatched into larvæ, these larvæ never reached the adult stage, on account of the lack of food. As already stated, the eggs laid within short intervals of each other, were laid in separate, adjoining cells, and these cells were spread out over the cocoon or cocoons as a single, more or less flattened mass. From the same egg mass all three castes frequently emerged.

The Larval Stage of *B. auricomus*.

The larval stages of all three castes also present striking variations in duration. The average number of days spent in the larval stage for the three castes in this nest was as follows: drone, eleven and three-fourths; worker, thirteen and a fraction; queen, eleven and a fraction. Too few bumblebees of all castes were carried through from the egg to the adult stage to enable me to say that there is an average difference in the number of days spent by the three castes in the larval stage. The larvæ grow rapidly, and usually after four days or more, spin silken threads. As these silken threads hold together the thin walls of their cells, they are essential to the existence of the larvæ.

Any eggs or larvæ which may fall from their cells to the lower combs or floor of the nest, are carried out of the nest by the workers. The larvæ are fed on pollen and a fluid prepared by the queen and workers. Mr. Sladen (*The Humble-bee*, p. 28) says that this liquid food is a mixture of honey and pollen. In cells containing larvæ more than half-grown, a small hole is visible in the top of the cell. Through this opening, which is often the size of a common pin-head, the rapidly growing larvæ are fed. After a larva has just been fed, by pulling back the upper covering of the cell, one can see the liquid food injected by the queen or worker. This liquid food is often deposited in the hollow formed in the center of the curled larva, the larva of this species at this stage of development resting on one side. Before changing to a pupa, however, the larva assumes an upright position; the head end, which is at the top of the cocoon, being bent over and downward. Dwarf adults are, at least in many cases, the result of improper feeding, due to a bad position in the comb. Whether the workers and queens are the results of special feeding, as in the case of the honey bee, I am unable at present to say. The full grown larvæ of *B. auricomus* average 26 mm. in length and 6 mm. in width. The larva has a delicate, white skin, and presents in general, except in being much larger, the appearance of the larva of the honey bee. The fully grown larva spins its cocoon about three days before pupation.

After the cocoon is spun, the wax and pollen still clinging to it are removed by the workers or queen. The size of the cocoon enables one, in many instances, to separate the cocoons of the various castes from one another. The cocoons are light yellowish brown in color; thin-walled, and lack somewhat the toughness of the cocoons of *B. pennsylvanicus*. The following is a table of measurements of the cocoons of all three castes.

LARGEST COCOON.

Drone	13 mm. wide and 19 mm. high.
Worker	12 mm. wide and 15 mm. high.
Queen	15 mm. wide and 23 mm. high.

SMALLEST COCOON.

Drone	11 mm. wide and 17 mm. high.
Worker	7 mm. wide and 13 mm. high.
Queen	13 mm. wide and 21 mm. high.

AVERAGE COCOON.

Drone	12 plus mm. wide and 18 plus mm. high.
Worker	9 plus mm. wide and 14½ plus mm. high.
Queen	13½ plus mm. wide and 22 plus mm. high.

The pupal stage also presents variations in length. The average time spent by the three castes, in the pupal stage, was as follows: drone, nine and a fraction days; worker, nine and one-half days; queen, eleven days.

The Adult Stage of *B. auricomus*.

When the adult is ready to emerge, a slight movement within the cocoon is noticeable. An adult escapes from its cocoon by cutting around the cap of the cocoon and pushing up the lid thus formed. Frequently, the emerging adult is assisted in escaping from its cocoon by a worker or the queen. Immediately after emerging, the adult makes a search for the nearest supply of honey. A newly emerged bumblebee has a moist, matted, velvety appearance. That portion of the pubescence which is black in the older adults of this species, is in the young adults light gray, occasionally approaching a dark brick-red; those portions which are yellow in the older adult, being very pale, almost white, in the freshly emerged specimens. Adults seldom leave the nest until their pubescence has reached its normal color.

The first adult bumblebee to emerge is probably always a worker; at least in this nest, such was the case. The second worker emerged on June 26, the first drone on July 22, and the first queen on July 24. The drones of *auricomus* appear early in the season as compared with those of most other bumblebees.

Storage of Pollen and Honey.

For the first few days after emerging, the workers brood over the eggs, attend to the wants of the larvæ, clean out empty cocoons, and perform all those miscellaneous duties involved in a social type of existence. After that, besides helping within the nest, the workers usually leave the nest in search of pollen and nectar. On returning from a successful foraging trip, the honey is regurgitated either into the original honey-pot, or into empty cocoons used for the same purpose. Cocoons used for the storage of honey are capped over with wax. The pollen is scraped from the corbicula into empty cocoons used for that purpose. Before a worker scrapes off her load of pollen, she pokes her head into various empty cocoons, until she finds the right one for her purpose. After the pollen-containing cocoon has been found, the worker stands on the edge, facing away

from the cocoon, and inserts her hind legs down into the cocoon; then she proceeds by a quick, slicing, downward movement of the middle pair of legs, to remove the pollen from the corbicula. The spur on the end of the middle tibia probably serves as a lever to remove the pollen from the pollen-plate. The habit of storing pollen in empty cocoons away from the larval mass, would cause this species of *Bombus* to be classed as a "pollen-storer" by Sladen (Ent. Mon. Mag. 1899, p. 230). The pollen pellets once deposited, are then packed down by the same worker or by other workers; the head and mandibles being used in this operation.

Manipulation of Wax.

Wax is produced by the females between the basal abdominal segments as Sladen also found. The color of the pure wax is white. The wax is scraped from the dorsal parts of the abdominal segments by the hind legs, which are drawn down and over the abdomen; the inner sides of the hind metatarsi serving as brushes. After the hind legs have been drawn over the dorsum of the abdomen, the bumblebee stands on her fore- and middle-legs and rubs the inner surfaces of the hind tarsi together with an up and down motion. This rubbing of the inner surfaces of the hind tarsi removes the particles of wax, which fall down on the comb. Many times I have watched bumblebees scrape the wax from their tarsi in the manner described, and have never seen one select any particular spot for depositing it. It may be mentioned, however, that the wax is usually removed while the worker or queen is standing on the brood or egg cells. The particles of wax, after being dropped, are later usually picked up by other bumblebees and worked into the surrounding comb. Wax was produced in large quantities by the old queen, but I never found signs of wax on the new queens. Wax was never noticed on the workers until after the normal color of the pubescence had been assumed.

One queer feature of this nest was the addition of a number of cells similar in structure to the original honey-pot, and attached to the latter. On July 7, eight other cells had been added to the original honey-pot, making nine in all. Later some of these cells were destroyed by the workers, and the material transferred to another part of the comb. Of these nine cells, six were not used for any purpose, pollen was stored in one,

and honey kept in two others. The original honey-pot measured on July 3, twenty millimeters in height and seventeen millimeters in width.

Habits of the Drones and Queens.

The drones, besides fertilizing the queens, do not contribute much to the welfare of the colony. After emerging, the drone of this species stays in the nest for several days; then flies out, sometimes returning and sometimes not. While in the nest the drones are very alert, and always retreat to the bottom of the nest at the first alarm. On several occasions I have seen the drones assist in brooding over egg and larval cells. The males of *B. auricomus* have very large eyes which, together with several other characteristics, caused this species, along with others, to be placed by Robertson in a new genus *Bombias*. (Trans. Amer. Ent. Soc. Vol. 29, 1903, pp. 176, 177.) Dr. H. J. Franklin, however, does not accept *Bombias* as a valid genus, regarding it instead as a subgenus. (*Bombidæ of the New World*. Trans. Amer. Ent. Soc., Vol. 38, 1913, p. 410.) I have seen the drones of this species hovering for hours about a particular fence-post in the sun, and from there darting out from time to time. On one occasion, I tried for two successive days to catch a male of this species which persisted in alighting on a particularly high weed in a sunny situation, and was at length successful. Here also, it may be mentioned that *B. separatus* Cress., another member of the subgenus *Bombias*, with large eyes, has the same habit of selecting fence-posts, trees, and other prominent objects, and remaining about them for many hours. I have never seen a male of *B. auricomus* attempt to copulate with a queen in the same nest.

The new queens assist in the general work of the nest, and seem to get along very well together. The queens are probably fertilized by the males after leaving the nest. Hibernation of the young fertilized queens undoubtedly occurs, but I have never found a hibernating queen of this species, nor do I know of one having been found.

Remarks on Habits.

Of the several species of *Bombus* with which I have been working, *B. auricomus* has the smallest colony, is the most easily handled, and is the most cleanly in its habits. The fæces are

always deposited either outside the observation box, or in a far corner of the nest. When examining the comb in the observation box, I frequently removed all the glass covers, without danger of alarming the inmates or of being attacked by them. Of course, if one were to breathe into, or jar the nest, the workers would be aroused to action. It was evident that this species could be bullied by another species of *Bombus*, when one morning I discovered a worker of *B. pennsylvanicus* running about on the comb of this *B. auricomus* nest, and helping herself to honey. The *auricomus* workers were aware of the presence of this alien bumblebee, but acted as if afraid to attack the invader. On the other hand, when a worker of *auricomus* is introduced into a nest of *pennsylvanicus* it is immediately attacked and killed.

B. auricomus is probably victimized by most of the common parasites of bumblebees, but whether any species of *Psithyrus* infest the nests I am unable to state. One worker, which I found dead on the floor of the nest one morning, contained a full grown larva of Conopidæ, *Zodion obliquefasciatum* Macq. in her abdomen. Mites of the family *Gamasidæ* were also found in the nests.

In central Illinois, *B. auricomus* is not a very common species of bumblebee.

EXPLANATION OF PLATES.

Plate XXIII.

Fig. 1. View of the nest of *B. auricomus* Robt. on June 27, 1916, showing: *a*, queen; *b*, workers; *c*, original honey pot. Reduced.

Fig. 2. View of the nest of *B. auricomus* Robt. on June 27, 1916, showing: *a*, queen; leaving the nest; *b*, worker brooding on egg cells; *c*, cocoon full of honey, partly capped with wax; *d*, first empty cocoon, containing pollen; *e*, empty egg cell. Reduced.

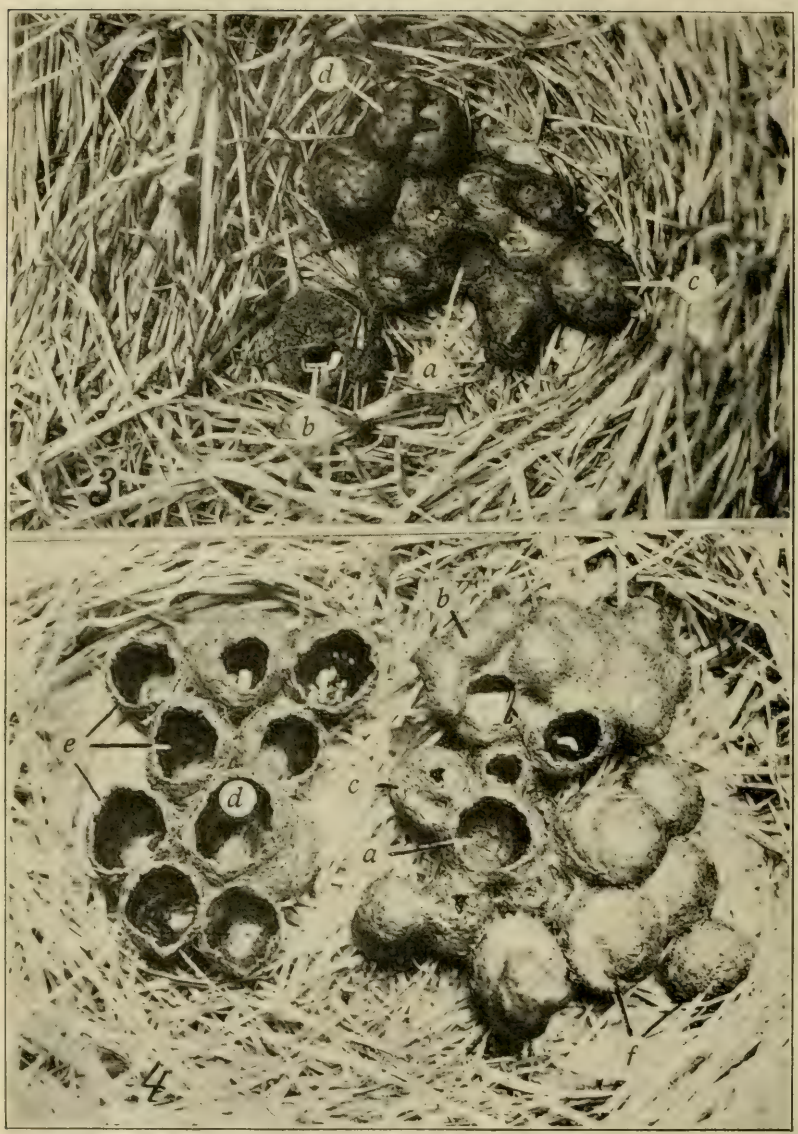
Plate XXIV.

Fig. 3. View of the nest of *B. auricomus* Robt. on June 27, 1916, showing: *a*, empty cocoon from which first worker emerged; *b*, original honey-pot; *c*, wax-covered cocoon; *d*, small brood cells. Natural size.

Fig. 4. View of the nest of *B. auricomus* Robt. on July 7, 1916, showing: *a*, first empty cocoon; *b*, brood mass, containing medium-sized larvae in separate cells; *c*, cocoon full of honey, partly capped with wax; d, original honey-pot; *e*, extra cells added to original honey-pot; *f*, wax-covered cocoons. Natural size.



Theodore H. Frison.



Theodore H. Frison.

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ADDITIONAL NOTES ON HEREDITY AND LIFE HISTORY IN THE COCCINELLID GENUS ADALIA MULSANT.

By Miriam A. Palmer.

In 1911 an article was published by the writer in the Annals of the Ent. Soc. of America, entitled "Some Notes on Heredity in the Coccinellid Genus *Adalia* Muls." This paper comprised all of the forms of Adalia at that time known to the writer to have been taken in Colo., viz., *melanopleura* Lec., *annectans Crotch, coloradensis* Casey, and *humeralis* Say. These forms were all found to interbreed freely, the different types acting as Mendelian units. In the spring of 1916 experiments were begun for the purpose of determining the biological relation between these forms and *A. bipunctata* Linn.

Adalia bipunctata Linn. as dealt with in this paper may be described as follows: Head black, with two white spots bordering the eyes. Pronotum pale with black M-shaped design with the broad pale margins, except in rare cases, immaculate instead of the black lateral dot as in *A. annectans.* Elytra brownish red with a rather large rounded black spot in the center of each. Legs black or brownish black. Length 4–5.5 mm., width 3.5–4 mm.

The appearance of the egg and larva in all stages seems indistinguishable from the rest of the *Adalia* group studied.* The color of the egg varied from pale lemon yellow to strong orange. This difference of color seemed to have no real significance, as eggs of both colors were laid by the same female and

*See Annals Ent. Soc. of America, Vol. VII, 1914, p. 228.

sometimes, in the same patch. The orange colored eggs seemed usually to be confined to the first egg patches laid by a female. Length of eggs was about 1.1–1.2 mm.

In the spring of 1916, through the kindness of Prof. R. L. Webster, two shipments of live *A. bipunctata* Linn were received from Ames, Iowa, March 21st and April 1st respectively, seven beetles in each shipment. Later about a dozen of this species were found in Colorado by Mr. L. C. Bragg, and Prof. C. P. Gillette. Owing to the unusual scarcity of the native species only a few of these were secured for the making of the crosses.

The first shipment from Iowa consisted of 6 unfertilized females and one male, the second 5 unfertilized females and 2 males. An *annectans* male was secured and introduced to each of these females. Though they readily mated, in only one instance did it seem to have any result. The eggs either continued to be infertile, or, if the female was already fertilized by a *bipunctata* male, the progeny continued typical *bipunctata*, though they were reared to the second generation.

A large number of beetles were reared from these females, mated with *bipunctata* males, in order to determine whether they were pure strains and what variation might appear. From one of these pairs (Figure 1), 54 beetles were reared in the first generation, all exactly resembling the father and mother, and 71 in the second generation, all true to type except 3, one of which was smaller spotted and two which possessed the lateral dot and lacked the basal white on the pronotum, and had the elytral spots ragged in outline with a slight projection or dot mesad and surrounded by a yellowish halo. From another of these females (Figure 2) mated with the same male there were produced in the first generation 23 beetles exactly resembling the parents, in the second generation, 16 beetles showing exactly the same characters. Another female (Figure 3) with the same male as above produced in the first generation 18 beetles, all normal. Another *bipunctata* female with a *bipunctata* male (Figure 4) produced 39 beetles in the first generation, all true to type, and 15 in the second generation, also true. A number of the first generation from this beetle were put with a number of the first generation from the first mentioned beetle (Fig. 1) and 11 beetles resulted, all apparently typical

bipunctata. Still another pair of these beetles (Fig. 5) produced in the first generation 9 beetles like the parents excepting that 2 have slightly smaller spots, in the second generation 4 beetles all typical.

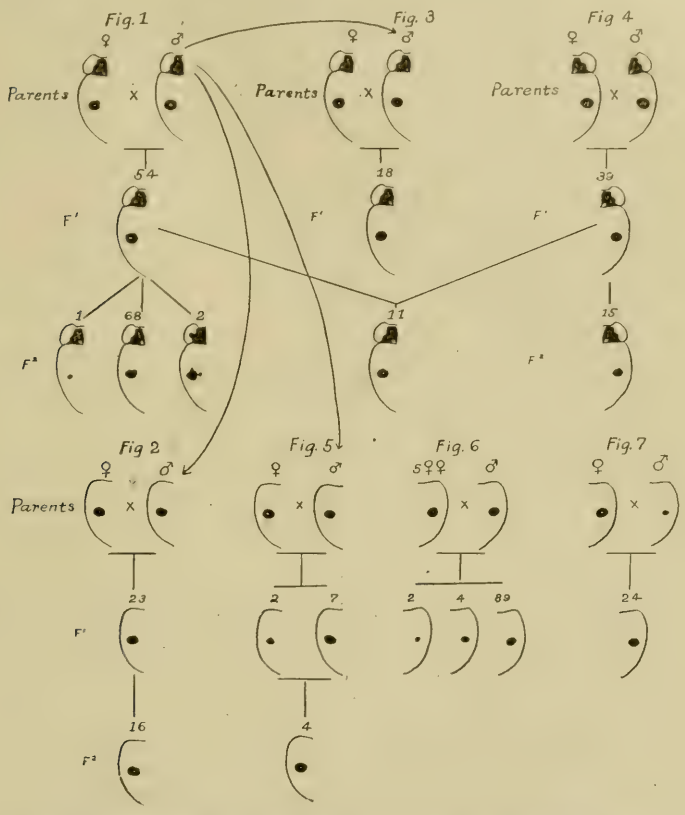


Fig. 1. Pair of *bipunctata* beetles, from Iowa, and their progeny.
Fig. 2. Pair of *bipunctata* beetles, from Iowa, and their progeny. (Male same as Fig. 1.)
Fig. 3. Pair of *bipunctata* beetles, from Iowa, and their progeny. (Male same as Fig. 1.)
Fig. 4. Pair of *bipunctata* beetles, from Iowa, and their progeny.
Fig. 5. Pair of *bipunctata* beetles, from Iowa, and their progeny.
Fig. 6. Five *bipunctata* females and 1 male, from Iowa, and their progeny.
Fig. 7. One female from Fig. 6 mated with a *bipunctata* male, from Colorado, and progeny.

One of these *bipunctata* females (Figure 8) previously unfertilized, mated with the same *annectans* male, as had been offered without result to the above females, produced in the first generation 3 *bipunctata* beetles with moderately small

spots. One of these, a female, was mated with its *annectans* father and produced 3 small-spotted *bipunctata* and 2 typical *annectans*. Another of this lot of first generation females was mated with an *annectans* male from out of doors (Figure 9) and the first egg patch resulted in 3 *bipunctata*, 2 fairly small-spotted and one with a dot mesad of the elytral spots. The second egg patch gave 1 *bipunctata* normal, 1 *bipunctata* with spots reduced to dots, and 1 *annectans*. The original female (Figure 8) was then mated with a small-spotted *bipunctata* male (Figure 11) and 16 large-spotted *bipunctata* resulted.

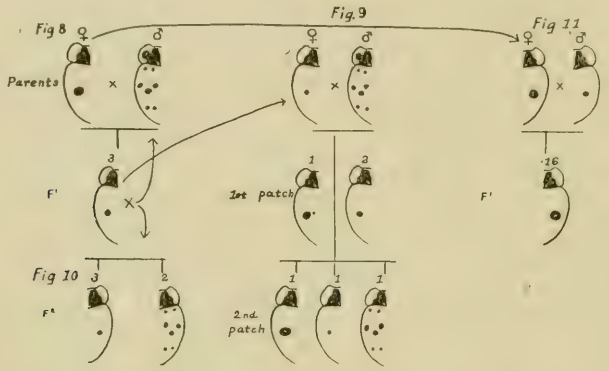


Fig. 8. *Bipunctata* female from Iowa mated with *annectans* male, and progeny.
Fig. 9. Female of F^1. generation of Fig. 8 mated with *annectans* male, and progeny.
Fig. 10. Female of F^1. generation of Fig. 8 mated with *annectans* male (father).
Fig. 11. *Bipunctata* female of Fig. 8 mated with *bipunctata* male from Colorado.

The 5 other females from Iowa were put together in one cage with a *bipunctata* male (Figure 6) and from the eggs 95 beetles were reared, all *bipunctata*, 2 small-spotted, 4 medium-spotted, and the rest of the same size of spots as the parents. One of the females was separately mated with a *bipunctata* male with small spots (Figure 7), and there resulted 24 *bipunctata* with spots the same size as the mother.

From the *bipunctata* beetles taken in Colorado there were also a considerable number of beetles reared. These were taken in Denver on two occasions, ten on April 19th by Mr. L. C. Bragg, and three on April 28 by Prof. C. P. Gillette. The first lot consisted of 6 females and 4 males and the second lot were all males and small-spotted. From one female (Fig. 12) mated with a *bipunctata* male 29 beetles were reared in the first generation, all apparently normal except that one was smaller-

spotted, and 6 in the second generation, all apparently normal *bipunctata*. Another female (Figure 13) mated with a *bipunctata* male produced in the first generation 11 beetles, 4 with spots the same size as the parents and 7 smaller-spotted and in the second generation 16 beetles like the grand-parents.

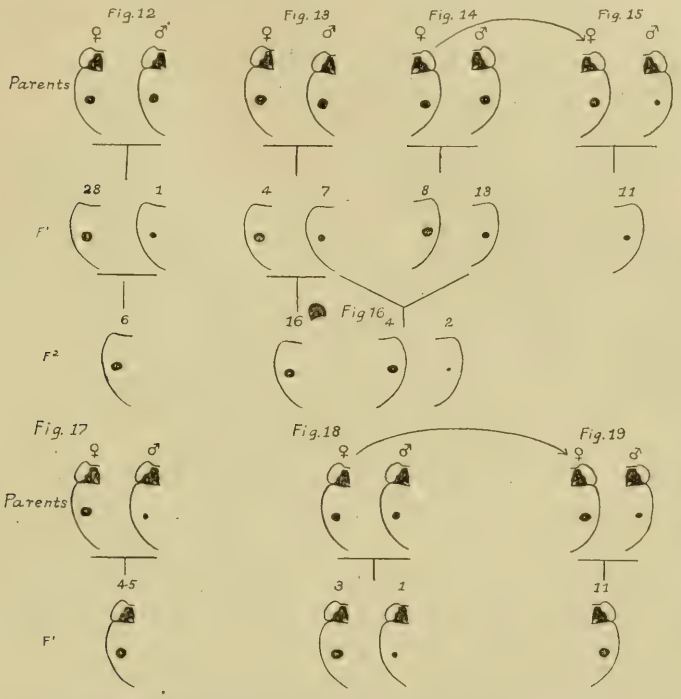


Fig. 12. Pair of *bipunctata* beetles from Colorado, and progeny.
Fig. 13. Pair of *bipunctata* beetles from Colorado, and progeny.
Fig. 14. Pair of *bipunctata* beetles from Colorado, and progeny.
Fig. 15. Pair of *bipunctata* beetles from Colorado, and progeny, (female the same as Fig. 14).
Fig. 16. Progeny of F^1. or F_1 of Fig. 13 and 14.
Fig. 17. Pair of *bipunctata* beetles, from Colorado, and progeny.
Fig. 18. Pair of *bipunctata* beetles, from Colorado, and progeny.
Fig. 19. Pair of *bipunctata* beetles, from Colorado, and progeny, (female the same as Fig. 18).

Another female (Figure 14) mated with a large-spotted male produced in the first generation 21 beetles, 13 more or less small-spotted and 8 fairly large-spotted. This female was then mated with a small-spotted male (Figure 15) from Denver and from this union 11 *bipunctata* were produced, all rather small-spotted. From a cage containing the small-

spotted beetles of the first generation of the last two females (Figures 13 and 14) eggs were reared (Figure 16) which resulted in 6 *bipunctata*, 2 of which had *very* small spots. From another pair (Figure 17) there were reared 45 large-spotted *bipunctata* in the first generation. Another of these females, (Figure 18) mated with a *bipunctata* male medium-spotted, produced 4 *bipunctata*, 3 normal and one rather small-spotted; mated later (Figure 19) with a small-spotted *bipunctata* male it produced 11 beetles, all with good-sized spots.

All of these *bipunctata* beetles were evidently pure strains, as no other forms appeared in the progeny though large numbers were reared and most were carried through the second generation. The size of the spots evidently varies and seems to act merely as a fluctuating variation, though it appeared oftener in some strains than in others. It probably acts the same as the size of the spots in *annectans* discussed in the former paper of 1911. The marking on the pronotum, too, seems to vary so that the white lateral area may be broken into (Figure 1), so as to form the black lateral dot.

In the early part of May an *annectans* female (Figure 20) was taken on the campus and soon laid a patch of eggs, fertilized before capture. From this egg patch there developed 16 beetles, viz., 3 *annectans*, 4 *melanopleura* with white area on the pronotum, 2 *melanopleura*, normal, with lateral dot on the pronotum, 4 *bipunctata* with very small spots, and 3 *coloradensis* with considerable variation, 2 with the typical white area on the pronotum and one with it broken by a black lateral dot, more posteriorly placed than in *annectans*. A few second generation individuals were reared from most of these forms. The *annectans* beetles produced 1 *annectans*. The *melanopleura* with white area mated with each other, produced 3 normal *melanopleura* with lateral dot; one of the males mated with an *annectans* female produced 4 beetles, 2 *annectans* and 2 normal *melanopleura* with lateral dot. These results seem to signify that the lack of the lateral dot may occur in *melanopleura* as a fluctuating variation, as these specimens could not have been influenced by the other element of the hybrid as they were either *annectans* or else *humeralis* hybrids, both of which have always proved to be recessive to every character of *melanopleura*.

The bipunctata specimens produced 1 *annectans* and 1 *humeralis*, which signifies that there were two kinds of *bipunctata* hybrids, viz., both *annectans* and *humeralis*. One pair of *coloradensis* specimens, one with white area and one with

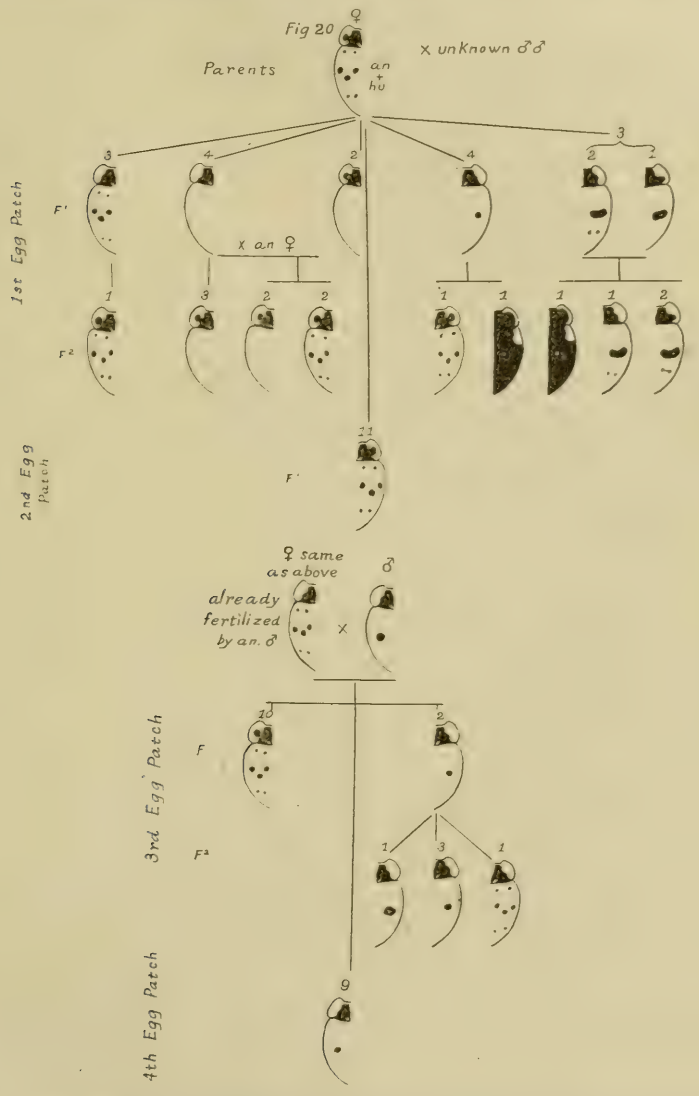


Fig. 20. *Annectans* female captured out doors, already fertilized, and progeny, 3rd and 4th egg patches laid after fertilization of the female by a *bipunctata* male taken in Colorado.

posterior lateral dot, produced 4 beetles, 1 *humeralis* and 3 *coloradensis;* 1 of the latter with white area and 2 with posterio-lateral dot. This dot seems in this case to be a fluctuating variation, for the appearance of the *humeralis* in the progeny proves the parents both to have been *coloradensis* hybrids with *humeralis;* in other words, each presented a single strain of *coloradensis* and neither one seems to be a Mendelian dominant. Evidently from these last two cases, the *annectans* mother of all these must have been an *annectnas humeralis* hybrid and must have been mated with several males very nearly at the same time. These males must have born *annectans, melanopleura, bipunctata and coloradensis.*

After 9 days the above female laid another patch of eggs from which 11 beetles were reared, all *annectans,* which seems to signify that the *annectans* male was the last one which mated with the female and the most of the eggs in the first patch had already been fertilized by the former males. The second patch, however, was fertilized entirely by the *annectans* male, the fresher spermatozoa evidently taking precedence over the older ones.

This female was then mated with a *bipunctata* male and the next egg patch, laid within 3 or 4 days produced in the first generation 10 *annectans* and 2 *bipunctata* with small spots, in the second generation from the *bipunctata* beetles there were reared 1 normal *bipunctata,* 3 with fairly small spots and one *annectans.*

A fourth patch of eggs laid 6 days later was reared and 9 beetles matured, all *bipunctata* with small spots. These beetles emerged during the latter part of June, but up to the 15th of August, when the experiment was discontinued, they had neither laid any eggs nor been seen in copulation. They were, however, seemingly in perfectly healthy condition and probably would have hibernated and laid in the spring, or they might have begun breeding September 1st. The latter supposition is based on the theory that the inactivity may have been due to the period of cessation during July and August mentioned by D. E. Fink in his bulletin 1915 of the Virginia Experiment Station. A period of great difficulty in rearing *Coccinellids* at this season of the year has been noted in Colorado by the writer, but has been heretofore attributed rather unsatisfactorily to various other causes.

In this case every one of the forms under consideration appeared from the eggs of a single female, but hybrids of *bipunctata* were discovered only with *annectans* and *humeralis*.

On the 25th of May an egg patch was obtained from another *annectans* female (Figure 21), taken out of doors already fertilized. Though, for 5 days before laying the eggs, it had been mated with a *bipunctata* male, the one used in Figure 1, 2, 3, and 5, no trace of *bipunctata* appeared in the progeny. Thirteen beetles matured, 3 *annectans*, 4 normal *melanopleura* with lateral dot, 3 *melanopleura* with white area, and 3 *coloradensis* with a lateral dot placed more posteriorly than the

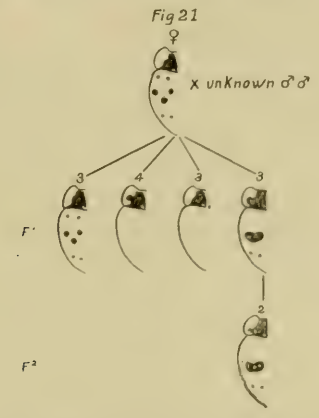


Fig. 21. *Annectans* female captured, already fertilized, and progeny.

lateral dot of the other forms. In the second generation from the *coloradensis* cage, 2 beetles were reared and they were both *coloradensis* with the posterior lateral dot.

Judging from this case together with the similar results with the *coloradensis* progeny of the former *annectans* female, it is evident that *coloradensis* often possess a lateral dot, more posteriorly placed than in other forms, instead of the broad white area as given in the former paper of 1911. Both these patterns are mentioned in the original description by Casey. The above-mentioned lateral dot seems in this case to have bred true, but considered with the case in Figure 20 it can hardly be considered more than a fluctuating variation, since in that case a pair of *coloradensis humeralis* hybrids, one with the dot and one with the white area produced progeny both with and without the dot.

Conclusions: (1) *Bipunctata-annectans* hybrids were formed both in the laboratory and in state of nature. More difficulty was experienced, however, in securing crosses than in the previous experiments with only the native forms, but this may have been partly accidental. They would mate readily enough, but in only comparatively few instances were the eggs affected. The hybrids when formed seemed just as healthy and fertile as the other hybrids.

(2) *Bipunctata-humeralis* hybrids were formed out of doors and these, too, were fertile.

(3) The appearance of the *bipunctata-annectans* and the *bipunctata-humeralis* hybrids was identical in these cases. *Bipunctata* dominated completely in the markings of the pronotum and also in the spots of the elytra unless the smaller size of the spots was a modification. The spots were no smaller though than those that occasionally appeared in what seemed to be pure strains of *bipunctata*. Evidently in the *bipunctata-annectans* hybrid the size of the spot is determined by the marking of the smaller spotted parent, black being recessive in these beetles (see paper of 1911). Except in rare cases the smaller spotted parent is most liable to be *annectans*. Since *bipunctata* seems to be small spotted in some cases there is no constantly reliable character whereby to distinguish the hybrid except that it is very likely to be more or less small-spotted.

Why the size of the spot should be reduced in the *bipunctata-humeralis* hybrids is far from clear. In these experiments it could hardly have been due to mere fluctuation of the *bipunctata* element or the results would not have been so constant. For example: In the case of Figure 20, first, third and fourth egg patches 15 hybrids were obtained from the *annectans-humeralis* female crossed with a *bipunctata* male. The chances are that half of these were *bipunctata-annectans* and half were *bipunctata-humeralis* hybrids, which should be enough to show some variation, but the dot seems to be of practically uniform size in all.

(4) *Bipunctata*, in the hybrid form, was reared from the same patch of eggs as were also *melanopleura* and *coloradensis*, and this seems very good if not indeed, conclusive evidence that they are able to interbreed with these forms too, though the exact hybrids were not all produced.

(5) In *melanopleura*, *coloradensis* and *bipunctata* there were discovered variations in the markings of the pronotum, viz.: in all these forms the lateral dot may be either present or absent. So *melanopleura* with the white area on the pronotum are not necessarily *melanopleura-coloradensis* hybrids as supposed in the paper of 1911 or *melanopleura-bipunctata*, as might be expected. Vice versa, since *bipunctata* sometimes possess the lateral dot it would not be surprising to find *melanopleura-bipunctata* hybrids bearing it and so not differing in appearance from typical *melanopleura*. The lateral dot in *coloradensis* being differently placed and not coinciding with the regular dot, the white area would be expected to appear in the hybrid.

In *melanopleura* the presence of the lateral dot is infinitely the more common form, in *coloradensis* it seems to be rather uncommon, and in *bipunctata* it is extremely rare.

In 1914 a second article was published by the writer in the Annals of the Ent. Soc. of Am. entitled "Some Notes on Life History of Ladybeetles." As the writer had not then taken *bipunctata* in Colorado, it was not included in those experiments. In order to complete this record a few life history notes were taken on this species in connection with the foregoing experiments.

Life cycle records were taken as follows:

Egg stage (6 records) 3–7 days.
Larva stage (2 records) 9–10 days (in hot weather).
Pupa stage (2 records) 4–5 days (in hot weather).
Egg to adult 16–30 days.

Adult stage; no records taken except on hibernating beetles, a number of which lived and mated and laid eggs in the laboratory until August 15, when the experiment was discontinued and they were killed and pinned up. Judging from this the hibernating form must be able to live 12 months more or less. The life cycle records vary greatly according to the temperature of the weather. In the spring each stage took about twice as long as in the warmest part of the summer with the thermometer from 87 to 93 degrees.

One satisfactory egg record was taken and in 3 months and 15 days this female laid 1,180 eggs. The beetles laid from 12 to 35 eggs in a patch and would sometimes lay 2 patches a day and would also often skip several days and then lay again.

Before being fertilized the beetles would lay only a few scattered eggs but in a day or so thereafter they would lay plentifully and in good patches. Fertilization seemed to last several weeks, but not for the season. One female observed was found to be laying infertile eggs 35 days after being isolated from a male. The spermatozoa of the later male seem always to take precedence over all former, so that the eggs which have not been already fertilized produce the characters of the last male. The earliest egg patch was obtained April 1st and the earliest beetles emerged May 1st.

A few feeding records were taken on both *bipunctata-annectans* and *annectans* larvae. These were taken in very warm weather, the thermometer being 87° to 93° each day. The larvae, accordingly ate their maximum and finished their life cycle in the minimum time. In colder weather they ate much less per day and the period of development was according prolonged. These experiments were conducted with the greatest care. The larvae were put into separate cages and the lice which were given for feed were counted as carefully as possible. Young of *Myzus circumflexus* were used for the first feed in each instance and after that *Chaitophorus negundinis* was used entirely. A check tube was kept to ascertain the number of lice dying naturally in a day, but it seemed to be of little account, as practically no lice seemed to die except from some disease or from capsid injury, and this turned the dead bodies brown, so that they could be easily distinguished in the larval cages. Some of the larvae had already filled up on the unhatched eggs of their patch before isolation, which of course did not count in the food record, also whenever there was any doubt as to the number of lice eaten the smaller alternative was taken. The young lice that may have been born after being put in the cage were not regarded, as they would not increase the bulk materially. The only difference they could make would be to add to the number left over and subtracted, which would reduce the number in the record, instead of exaggerating it. In these ways every precaution was taken against getting too large a count. The records are as follows:

	June 29	30	1	2	3	4	5	6	7	8	Total	Length Larva	Length Adult
bi. larva	H	10	M 7	M 45	23	M 60	100	80	P		325	7 mm.	5 mm.
" "	H	5	M 8	M 30	50	M 95	92	100	30	P	407	6.9 mm	5 mm.
an. larva	H	5	M 8	M 43	M 18	84	72	4	P		234	7 mm.	4.9 mm.
" "	H	10	M 13	M 30	37	M 38	94	100	7	P	323	7 mm.	5 mm.
" "	H	2	M 16	M 23	M 46	67	75	0	P		243	7 mm.	4.5 mm.

H—hatched. M—molted. P—pupated. bi.—bipunctata. an—annectans.

The *bipunctata* specimens in this experiment were really *bipunctata annectans* hybrids.

The *annectans* larvae, it will be observed, have eaten less than the *bipunctata* individuals, but this is probably only accidental, as the larvae of the same species seem to vary greatly, and these specimens were all the same size, and should therefore be of equal capacity. It is interesting to notice that the one that ate the most lice was slightly the shortest when full grown.

These results seem to differ somewhat from those given by Mr. Clausen, in California, in his paper of 1916.* The difference is probably due to climatic conditions influencing the rapidity of development, as the totals, it will be seen, do not differ any more from these results than has been found as a common variation between individuals of the same species even under the same conditions. During the spring when the weather was cool the beetles ate much less per day and the life cycle periods were much longer. Though no counts were made at this time there is no doubt but that they would not disagree materially with the records of Mr. Clausen.

Perhaps the following observation on *Hippodamia convergens* might also be added. On July 18, 1916, this species was found by the writer congregated in heaps of hundreds in grassy crevices in the solid granite top of a foot-hill, 38 miles northwest of Ft. Collins, at an altitude of a little over 8,000 feet.

*Life-history and Feeding Records of a Series of California Coccinellidae by Curtis P. Clausen, University of California Publications, Technical Bulletins Entomology, Vol. I, No. 6, pp. 251–299, June 17, 1916.

Two other such cases were reported during the same summer and fall, about ten and fifteen miles from Ft. Collins, the one on the granite top of Horse Tooth Mountain, altitude 7,160 feet, and the other at about the same elevation. In the latter case the beetles were said to be massed on a small pine tree. Another mass was reported to have been found on a bare mountain-top west of Denver at about the same time of year as the former instances. In March, 1917, on the plains two miles west of Ft. Collins, Mr. L. C. Bragg observed hundreds of *convergens* coming out from hibernation from under rocks and stones near the road side.

THE NERVOUS SYSTEM OF THYSANURA.

William A. Hilton.
(Department of Zoology, Pomona College, Claremont, California).

The central ganglia of representative genera, Campodea, Evalljapax, Lepisma and Machilis were examined.

The first important papers dealing with any of these genera were those of Grassi 1885 and 1888. In both of these, brief discussions of the nervous system are given, but no clear picture of the complete nervous system. Probably the most copied figure of the nervous system of any thysanuran is the one of Oudemans, 1887. In this, a drawing of the complete nervous system of Machilis is given which could hardly be improved upon, but the position of the optic lobes, brain and other cephalic parts are not shown in the relations we find them within the body of the animal. In this figure there is a representation of the fine medial nerve. Another paper by Grassi in 1888 shows the general form of the nervous system of Campodea and Japax and a number of details are clearly given. Bottger, 1910, on Lepisma saccharina L. gives a very complete account of the brain and shows it to be very nearly as complex as that of other insects.

Campodea undoubtedly has the most primitive, or at least, the simplest nervous system of any of these insects. The brain is provided with antennal nerves well towards the forward end. The first ventral ganglion is nearly under the brain, then there follow three large thoracic ganglia and seven small abdominal ganglia with the last one a little larger than the rest. This corresponds to Grassi's figure, but this one gives greater detail. It was drawn from gross dissection. No frontal ganglion is shown as one was not clearly recognized in section or dissection. (Figure 1).

Japax or Evalljapax in this case, differs quite a little from Campodea in appearance, the brain is of different shape, and as it is also without eyes, the forward antennal nerves are the most marked. The ventral ganglia are a little more oval, branches are more prominent and there is one more abdominal ganglion. The last abdominal as in Campodea, is a little larger

than the rest. The drawing is from a fresh, completely removed central nervous system. (Figure 2).

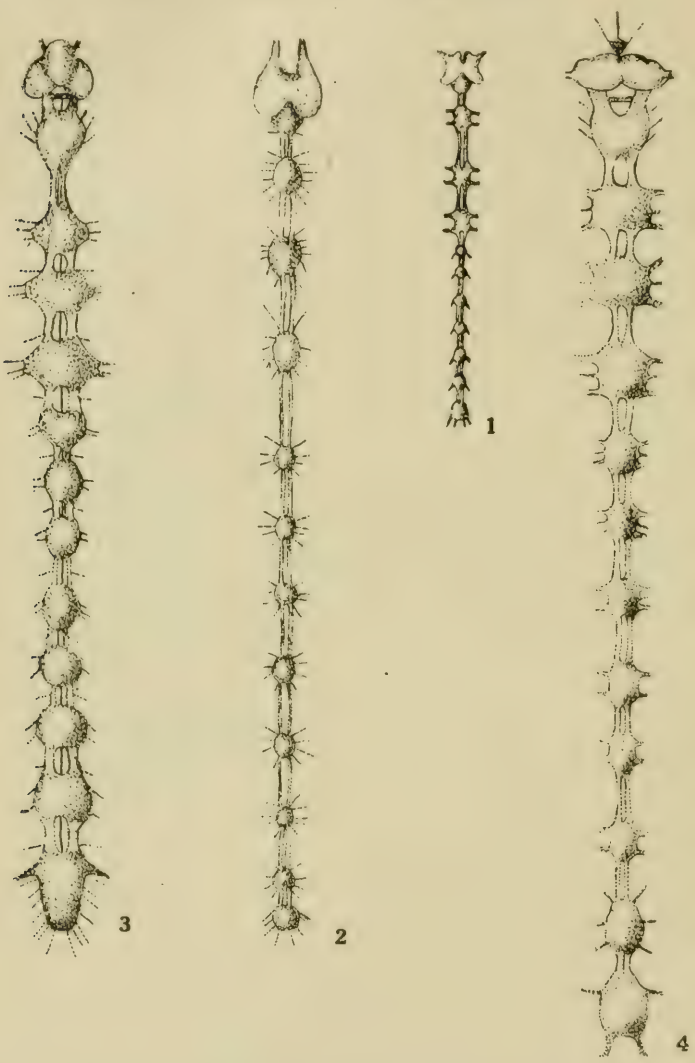


Fig. 1. Central nervous system of Campodea from above. × 10.
Fig. 2. Central nervous system of Evalljapax from above. × 10.
Fig. 3. Central nervous system of Machilis from above. × 10.
Fig. 4. Central nervous system of Lepisma from above. × 10.

Machilis has a more complicated brain, partly because of the eye connections; it also has a general transverse direction, as

shown in the figure and has quite a little depth. The frontal ganglion is not shown in the figure. The first ventral ganglion is large, so are the three thoracic ganglia. There are eight abdominal ganglia differing somewhat in size and somewhat from Oudemans figure. The median ventral nerve was found much as figured by Oudemans. Perhaps the most marked feature was in the backward extension of the optic lobe region because of the position of the eyes. The figure does not agree with Oudemans, largely because the brain is shown in its natural position as it is found in the head. (Figure 3).

Lepisma resembles Machilis very closely, but because of the more lateral and cephalic eyes the brain is more transverse when viewed from above. The frontal ganglion is shown in the figure. (Figure 4).

TRACHEAL DISTRIBUTION.

Trachea can be best studied by removing the ganglia and mounting while still fresh in glycerine. The air in the tracheal tubes remains for a few minutes and the distribution of the trachea may be seen. I found the tracheal distribution much as in the larva of another species. In general, the brain seems supplied by three main trachea on each side. The subesophageal ganglion by two main branches on each side, each ventral ganglion below this with one on each side, but the last ganglion with two branches at least, one of which often has some association with the branch of the next to the last ventral ganglion. Two branches seems to be the usual number for the last ganglion. (Figure 7-16).

It was very difficult to study trachea in the small Campodea because it was hard to remove the ganglia in the first place, and second because the trachea remained visible only for a short time. The lower smaller ganglia were each supplied with a single pair of branches, but the supply to the larger cephalic ganglia seemed to be by two sets of main lateral trachea from above and below, each set giving off branches as shown in the figure. The abdominal ganglia are supplied more simply. In none of the centers was there the branching of the tracheoles to the degree found in Evalljapax.

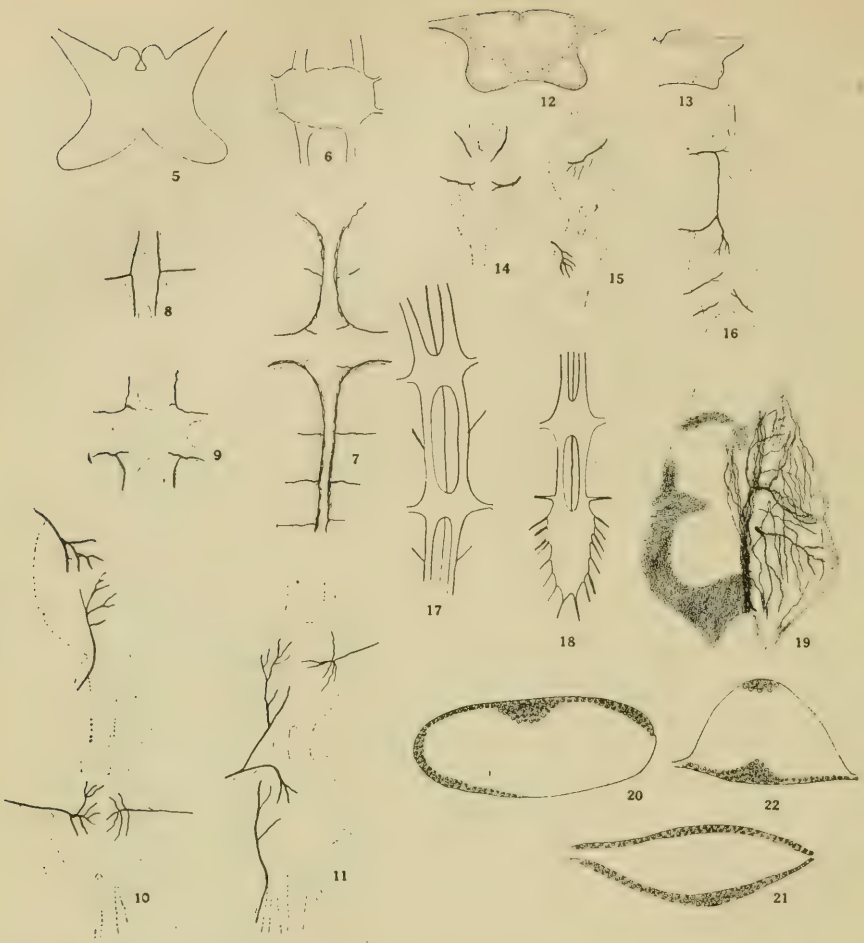


Fig. 5. Brain of Campodea from above. × 75.
Fig. 6. Thoracic ganglion of Campodea from above. × 75.
Fig. 7. Region of last two thoracic ganglia above and some of the abdominal ganglia in the lower part of the figure, from Campodea, showing the lateral tracheal tubes. × 75.
Fig. 8. One of the abdominal ganglia of Campodea showing tracheal tubes. × 75.
Fig. 9. One of the thoracic ganglia of Campodea showing tracheal tubes. × 75.
Fig. 10. Tracheal distribution in the subesophageal and first thoracic ganglion of Evalljapax. × 50.
Fig. 11. Tracheal distribution in the last two ganglia of Evalljapax. × 50.
Fig. 12. Brain of Lepisma showing where the deeper masses of cells are as seen from a methylene-blue preparation. × 20.
Fig. 13. Part of the brain of Lepisma from below showing areas of most abundant cells. × 20.
Fig. 14. Subesophageal ganglion of Lepisma showing distribution of trachea.
Fig. 15. Third thoracic and first abdominal ganglia of Lepisma showing tracheal distribution. × 20.
Fig. 16. Last two abdominal ganglia of Lepisma with tracheal distribution. × 20.
Figs. 17 and 18. Abdominal ganglia of Machilis, showing medial nerve. × 22.
Fig. 19. Brain of Evalljapax from above showing distribution of thickest masses of cells on the left side and the distribution of tracheal vessels on the right side. × 50.
Figs. 20 and 21. Supra- and subesophageal ganglia of evalljapax as shown in longitudinal section. × 50.

GENERAL CHARACTER OF THE BRAIN.

One of the chief differences between the brains of Campodea and Evalljapax as compared with Lepisma and Machilis is due to the lack of eyes in the first two. There are numerous differences between the brains of the first two genera. The shape of the brain of Campodea is given as it appears when viewed from above in Figure 5. Longitudinal and cross sections through the brain show the ventral parts largely without cells. (Figures 23-26).

The cephalic and mid-dorsal regions are not so well supplied as the lateral dorsal and caudal regions; the caudal lateral region of the brain has the largest mass of cells. Many fibers run from the brain, from or to, forward, median or lateral parts down the connectives to the subesophageal ganglion and farther. There are also numerous small bundles which connect all parts. In the latero-caudal region there are central masses of denser fibers. Three well-marked masses at least may be seen on each side near the dorso-lateral region, Fig. 23. These may represent the areas which in other species help form the mushroom bodies. The brain of Evalljapax is shown from above in Fig. 19. On the right side is shown the position of the tracheal tubes of that side and on the other the position of the larger cell areas as shown in the methylene blue preparation. The shape of the ganglion is quite different from that of Campodea, as the drawing indicates. There are cells on the dorsal side of the brain, but they are few compared to the other great areas indicated in the drawing. In section the brain seemed simpler in structure than that of Campodea, but this in part may have been the fault of the preparation. As in Campodea, the ventral regions of the brain are without cells. No clear indication of mushroom bodies was seen, and the connections between different parts of the brain and the connectives and subesophageal ganglion seemed less marked.

Machilis and Lepisma also differ from each other to a marked degree in brain structure and arrangement. The general distribution of cells above and below is shown in two figures, 12 and 13, which were stained in methylen blue. In an adult there seem to be not as many cells in proportion to the general area of fibers as in some of the other genera. The middle line both above and below is largely without cells as shown in Fig. 32,

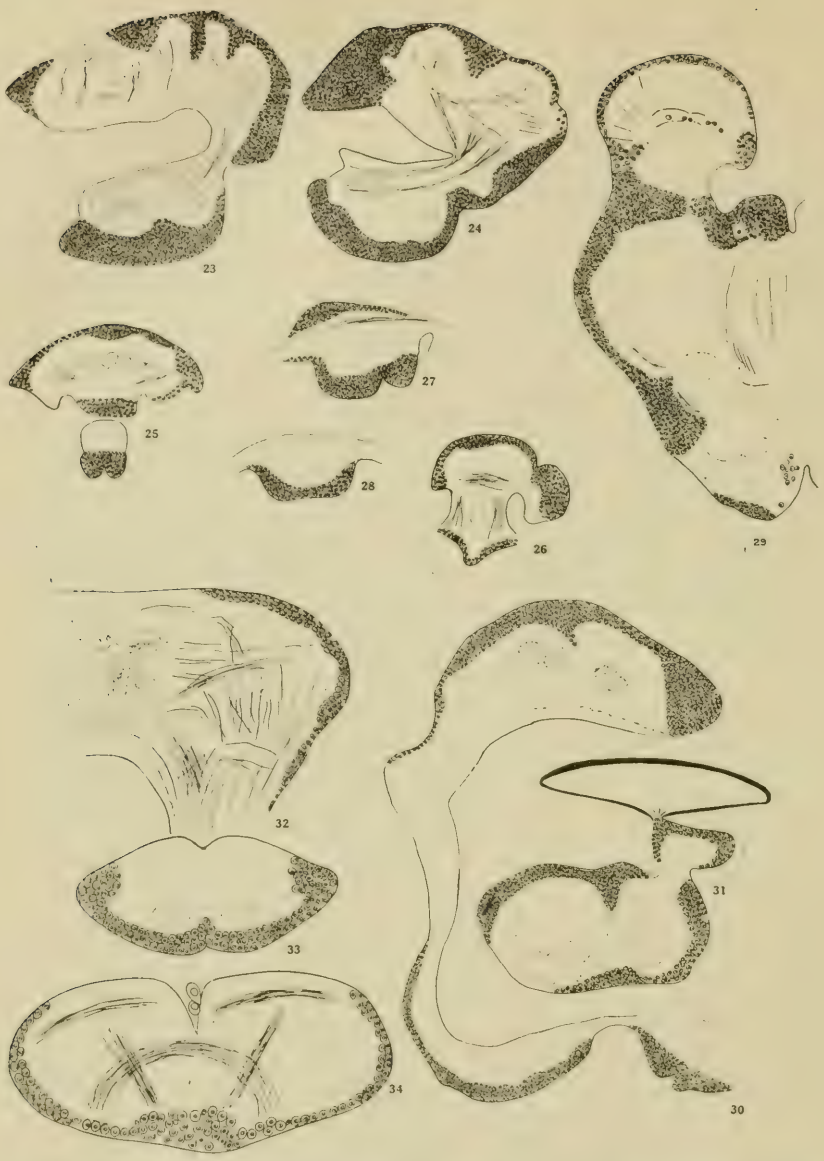


Fig. 22. Cross section through the first thoracic ganglion of Evalljapax. × 50.
Figs. 23 and 24. Longitudinal sections through the brain and ventral ganglion of Campodea. The cephalic end is to the right and the brain is above. × 150.
Figs. 25 and 26. Cross sections through the brain and first ventral ganglion of Campodea taken at different levels. × 150.
Fig. 27. Longitudinal section through the first thoracic ganglion of Campodea, the dorsal side is above, the cephalic end at the left. × 150.
Fig. 28. Longitudinal section through the second thoracic ganglion of Campodea, the dorsal side is up. × 150.
Fig. 29. Longitudinal section through the brain of Machilis. Only one-half is shown. The optic lobe region is at the top of the figure. × 150.
Fig. 30. Longitudinal section through the brain and two ventral ganglia of Machilis. × 150.

which is nearly a cross-section through the brain of an adult. In this a much more complicated structure of fibers and fibrils is presented than in any of the others so far compared. The stalks and roots of the mushroom-bodies are shown in Fig. 32, also the so-called central body. The arrangement of the fibrillar material of the mushroom seems to have a different arrangement and development than in Lepisma saccharina studied by Bottger, 1910. In his descriptions and figures an anterior and posterior division of the cap of the fibrous material or "Traube," is given but in the species studied at this time the "Traube" has a different position and is not clearly made up of more than one main lobe on each side. Each of these main lobes as shown in the figure has five secondary lobes instead of four shown by Bottger. In the region of these masses of fibrous material of the mushroom-bodies there are a number of irregular fibrous bundles which may represent other parts of this structure. On the whole, there is a fairly close resemblance to the brains studied by Bottger and differences may be due to the fact that this is not the species which he studied, but our most common local species whose exact identity has not yet been reported to me by special students of this group.

One of the first differences between the brains of Machilis and Lepisma is shown because of the different position of the eyes. The eyes of Machilis are connected with the caudal end and this dorso-caudal region forces the parts of the brain usually found here, farther forward. This is not an unusual condition among the brains of invertebrate animals, in some amphipod Crustaca as compared with nearly related isopods there is a similar shifting. In general, the posterior lobe region of the brain of segmented animals seems to represent its highest center, but shiftings such as just mentioned may often change the usual arrangements.

The second marked difference between Machilis and Lepisma at least in all specimens studied, both small and large, was in the

Fig. 31. Longitudinal section through the edge of the brain of Machilis, the section is through the eye above and to the right. The cephalic end is towards the left. × 150.

Fig. 32. Cross section through the brain of Lepisma, only the right half is shown. × 150.

Figs. 33 and 34. Cross sections through two levels of the first thoracic ganglion of Lepisma. The dorsal side is up. × 150.

way of a complete lack of anything which might strictly be called mushroom-bodies in Machilis. There are however groups of fibers in the proper region of the brain in specimens of all sizes, but these are hardly more marked than in Campodea. The usual distribution of cells was found in this genus. Some indication of the complex but usual arrangement of fibers in the optic lobe region is shown in the Figures. Association, projection and commissural fibers are easily demonstrated. (Figs. 29-31).

In all the brains examined, cells of the usual and well-known types for insect brains were clearly seen. Especially was this the case with the representatives of Lepisma and Machilis. In these also there were more differences between cells. In all, nerve cells were held in place and otherwise supported by neuroglia cells and neuroglia nets. In all, the fibrils within the central portions of the ganglia formed intricate tangles with the possibility of almost unlimited connections between parts. In the smaller and simpler species few well separated definite tracts were found, fewer than in Lepisma and Machilis. This is in part due to the fact that the cells, fibers and fibrils are not so large, but there may be other reasons.

The ventral ganglia in the different species differ greatly in complexity. They seem to be the simplest in Campodea and the most complex in Lepisma. In all, the more abundant cells as is usual, are ventrally placed and the dorsal cells are usually limited to the sides and to a small group in the mid-dorsal line.

If we consider the brain from its three main pairs of nerves or three main regions on each side to consist of three lateral segments, then we must consider the subesophageal ganglion from its nerves and lobings to consist of at least two segments and very possibly more. The first thoracic ganglion in Machilis and Campodea are evidently composed of two segments as shown in the figures. The cell arrangement and fibrous bands were found to be most complex in Lepisma. A few figures are shown of ventral ganglia of several of the species (Figs. 22, 27, 28, 33 and 34) and a more detailed examination of the first thoracic ganglion of Lepisma, is given below.

Beginning at the cephalic end we find the two masses of the connectives distinct for a short distance, then cells are located ventrally and laterally, being thickest on the mid-ventral line.

The cells are from one to three layers thick. The fibers in the middle line gradually form into a thick mass of commissural strands. There are also a number of diagonal fibers shown in the plane of the cross section. Farther down a second commissure makes its appearance as a narrow area crossed by coarse fibers. This crosses the center of the ganglion. Farther along a marked, much arched commissure occupies a short distance. The second commissure mentioned is quite extensive but not very thick. More dorsal arched fibers show farther along, these cross to some degree and come from lateral ventral cells, in part at least. In about the central part of the ganglion the other commissures and arched fibers have about disappeared and two small central masses of commissural fibers are evident and two ventral bundles of longitudinal fibers and marked crossings from the ventral to the dorsal side are seen. Farther along the two median commissures give place to one median arched commissure, while many branches are seen at various angles. This arched band disappears and another one comes in contributed to by marked masses of lateral cells. A few dorsal cells send their fibers straight into the ganglion from above. Farther down a more dorsal arched commissure comes in. Later there are two ventral straight bands of fibers and then a single median band reaching from side to side, then very soon the ganglion divides into the two ventral connectives. Cells on the ventral and lateral sides are seen at all levels. A few dorsal cells are seen near the central regions of the ganglion.

In the second thoracic ganglion a similar condition was noted, at least nine commissures were counted.

ABDOMINAL GANGLIA.

A general summary of the structure of abdominal ganglia of Lepisma will give an idea of their complexity:

1. Cells chiefly ventral are found in from one to two layers. The lateral ventral groups have three cell layers. There are a few mid-dorsal cells of various sizes.
2. There are in each ganglion a large number of commissures, both straight and arched, ventral and dorsal.
3. Fibers cross dorso-ventrally and caudally.
4. Fibers run short distances to nearby cell groups.

5. Cells of various sizes send fibers into the mass of the ganglion.

6. The longitudinal fibers to the connectives may be found in every part, but they are not always evident because of the many fine fibrils from various regions all woven in with them.

SOME GENERAL CONCLUSIONS.

The nervous systems of the four genera studied show some similarities but many differences. The general position and number of the ganglia is quite similar. Campodea, the least specialized in most respects, has one less ventral ganglion. The general shape of the four brains are quite different, even those without eyes are not alike and those with eyes have them so differently connected with the brain that the whole arrangement of the nervous system at this point is altered. Nerve cells differed chiefly in size and minor arrangements. The largest animals had the largest nerve cells. The general course of fibers and fibrils could be traced but special tracts were not traced very far. The general areas of mushroom bodies were determined for all. Only in Lepisma were these structures well developed, in Machilis and to a less degree in Campodea condensations of fibrils were taken to indicate them.

The general distribution of tracheal vessels is as follows: The brain has three main branches on each side, the subesophageal ganglion two branches from each side, the thoracic and abdominal ganglia as a rule have one branch each on a side and the last abdominal ganglion has usually two branches on each side. The brain of Campodea was not easily removed, so that the condition there was not so clearly made out, but the appearance so far as could be told was as stated for the rest. The thoracic and abdominal ganglia, however, have a distribution which is not like the rest. Possibly the long lateral trachea on either side with its branches to the ganglia may represent a more primitive if not an absolutely different condition. For this and other reasons I am inclined to think of Campodea separated from the other genera by a wide gulf. Japax seems separated from the rest by the next widest gulf.

The segregation of fibrils in clumps means a closer union in some places than others; this probably means: 1. Fibrils are closely massed that go in the same direction. 2. In some

places groups are closely correlated because of this relation to each other.

Nuclei are distinct from the fibers and fibrils; they are nutritive centers. The cell bodies also are important in metabolism, but they are not important enough centers for the mingling of many fibers. The individual fibers from cells are less important in the relationship of parts than the groups and masses of fibers and fibrils from many cells in conveying impulses. Association of fibrils seems more important outside of cells than in them. Why should not lateral as well as terminal contacts be important in conveying impulses? The fibrils are carried out in fibers, but the fibrils break away and are distributed in complex ways. It seems that an impulse may flow through ganglia like floods of water through a swamp. The impulses follow the lines of least resistance, if the bundle is large the direction is more definite, if small, of less importance. The nervous system of invertebrates might be compared to the heart and circulation of insects; it, like the heart, receives and passes on, but the distribution is not definite until there is a more perfect insulation. Insulation may be accomplished in several ways: (1) Bundles of fibers protect the central strands with a similar destination from loss to the surrounding parts; (2) The fibers in some cases remain distinct from each other, or the fibers are large and the inner fibrils are protected; (3) Neuroglia cells and neuroglia nets may help a little; (4) In vertebrates the more perfect insulation by means of myalin seems the most efficient protection.

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NEW MYCETOPHILIDAE FROM CALIFORNIA.

By Esther Guthrie, Stanford University, California.

During the fall, winter and early spring of 1915-16 a number of species of fungi was collected by the writer, in the environs of Stanford University for the purpose of studying Mycetophilid fauna.

The collection consisted of twenty-one species of fungi. These were determined for me by Prof. McMurphy of the Botany Department.

Some of these fungi furnished no insects while others furnished insects of several species, as shown in the appended table—the same species, in some cases, being found in more than one species of fungus.

The following species are described as new.

I. **Mycetophila maculosa** n. sp.

Male: Length 4 mm. Head yellowish; antennæ brownish; scape yellowish, flagellum gradually darkening from base to tip. Humerus yellow; pleuræ brownish. Two vittæ on dorsum, continuing over scutellum. Metanotum brown with narrow light median line. Hairs pale; setæ dark. Abdomen brown; posterior margin of second and succeeding segments narrowly yellow; Hypopygium (Plate XXV, A) coxæ and legs yellow; middle and hind coxæ with spot on posterior surface. Tips of middle and hind femora and metatarsi narrowly dark brown. No setæ on flexor surface of middle tibiæ; two ranges of setæ on extensor surface of hind tibiæ. Fore metatarsis about 7-8 as long as tibiæ; hind metatarsi about .9 as long as remaining joints taken together. Wing, yellowish gray, hyaline; dark brown spot at cross veins; barely clouded nearly midway between cross veins and apical margin, extending over marginal and first submarginal cells. Branches of cubitus not divergent. (Plate XXV, Fig. 1a). Halteres yellow.

Female: Same as male, with some little variations in color.

Reared from *Pleurotus ostreatus.* California Redwood Park, October, 1915.

Type No. 569-5-1, L. S. J. U., Entomological Museum.

II. **Mycetophila permata** n. sp.

Male: Length 4 mm. Head dark brown. Two ocelli contiguous to eye margin. Antennæ lighter brown, longer than head and thorax; scape, base of flagellum and palpi yellow. Thorax brown; three coalesced broad brown stripes on mesonotum, the two lateral ones

crossing the scutellum. Pleuræ dark brown, setæ brown, hairs yellow; metanotum brown. Hypopygium small, yellow (Plate XXV, B). Coxæ and legs yellow; brown spot on posterior lateral base of middle and hind coxæ. Tips of middle and hind femora brown. Middle tibiæ with three setæ on the flexor surface and two ranges of setæ on the extensor surface. Wing yellowish hyaline, with central brown spot and preapical fascia distinct across M_3 (Plate XXV, Fig. 1b). Halteres very pale.

Female differs in having a wing cloud in anal cell, close to Cu_2.

Reared from *Polyporus sulphureus*. Stanford University, October.

Type No. 569-2-1, L. S. J. U., Entomological Museum.

III. **Mycetophila alata** n. sp.

Male: Length 4 mm. Antennæ brown, palpi brown. Thorax brown; three dark brown, broad vittæ on the mesonotum. Pleuræ brownish; metanotum brown; setæ brown hairs pale. Abdomen dark brown; hypopygium small, yellow (Plate XXVI). Coxæ and legs yellow. Tips of middle and hind femora brown. Middle tibiæ with three setæ on flexor surface, and two ranges of setæ on extensor surface. Wings yellowish hyaline, with central brown spot and preapical fascia arising at tip of R_1 (Plate XXVI, Fig. 2a). Halteres pale.

Female: Differs in having scape and base of flagellum yellow, and wing cloud in anal cell.

Reared from *Polyporus sulphureus*. Stanford University, December.

Type No. 569-6-1, L. S. J. U., Entomological Museum.

IV. **Allodia dentica** n. sp.

Male: Length 5 mm. Lateral ocelli contiguous to eye margin; middle ocellus smaller and in a direct line with the two lateral ones. Vertex brown; face, palpi and scape yellow; flagellum brownish. Antennæ not as long as head and thorax together. Thorax yellowish; mesonotum with three brown stripes, the median one broadening anteriorly and extending forward to anterior margin of mesonotum. Scutellum yellowish with four large setæ near distal margin. Metanotum brown with narrow light median line. The pleuræ yellow; setæ dark brown; hairs pale. Abdomen yellowish; venters yellow, dorsum brownish, with 5th and 6th segments widely brown. Coxæ and legs yellow; tibial spurs brownish. Fore metatarsus shorter than the tibia and longer than the fore coxa. Five setæ above the fore coxa on the humerus; mesosternum without setæ; four setæ on mesosternum above hind coxæ. Second tarsal joint with a peculiar cupped and comb-like arrangement, with four sharp spines laterad and basal to the comb (Plate XXVII, Figs. 5, 5a). Wings yellowish hyaline; subcosta ends in R_1; cubitus forks slightly proximad of proximal end of cross-vein (Plate XXVII, Fig. 3a). Hypopygium as shown on Plate XXVII, lower forceps terminating in broad chitinized process which terminates in a row of blunt teeth (Plate XXVII, Fig. 3). Halteres yellow.

Reared from *Pleurotus ostreatus*, *Polyporus sulphureus*, October and December, 1915, California Redwood Park.

Type No. 569-1, L. S. J. U., Entomological Museum.

Va. *Genus **Johannseni** n. genus.

Front narrow; 2 lateral ocelli contiguous to eye margin; 1st and 2nd palpal joints slightly swollen, 1st little longer than 2nd, 3rd nearly equalling 1st and 2nd in length. Antennæ as long as thorax, slightly tapering toward tip. Abdomen compressed. Hypopygium of male small (Plate XXVI, Fig. 3, 4, 5, 6,). Legs short, femora moderately broad, flattened; tibia strong, enlarged at ends, with long spurs and strong setæ. Posterior basal setæ of hind coxæ present. Subcosta short, ending in R_1; costa not produced beyond the Rs. Fork of media under base of Rs. Cubitus forks distad of fork of M. Anal vein long and stout, reaching below fork of Cu. (Plate XXVI, Fig. 2b).

Differs from *Brachypeza* in wing venation, and antennal structure; from *Allodia* in structure of tibia, wing markings and size of tibial setae; from both in having but two ocelli, and in the presence of the strong first anal vein.

Reared from *Polyporus sulphureus*. October.

Type specimens deposited in museum collection at Stanford University.

Vb. **Johannseni aurei** n. sp.

Male: 5 mm. long. Robust. Antennæ as long as thorax; scape yellow; flagellum brownish. Palpi, proboscis and face yellow; vertex with darker transverse fascia. Hairs yellow; on each side a row of brown setæ extending ventrad from ocellus over the gena. Thorax yellow; scutellum with two basal brown spots, 4 marginal setæ. Row of yellow hairs on anterior margin of mesonotum. Pleuræ yellow. Abdomen reddish-yellow; hypopygium small (Plate XXVI). Coxæ and legs yellow, stout, tibia broadened at end. Femora reddish-brown at tips; tarsi brownish. Wings grayish hyaline with central black spot. Large preapical fascia, and cloudy about the margin. (Plate XXVI, Fig. 2b). Halteres yellow.

Female same.

Reared from *Polyporus sulphureus*. October. California Redwood Park.

Type No. 569-7-1, L. S. J. U., Entomological Museum.

*I take pleasure in naming this genus for Professor Johannsen of Cornell University, who kindly compared my new species with types of nearly related species.

The following table shows the fungus host for each species of Mycetophilid collected.

FUNGUS	COMMON NAME	DATE	LOCALITY	MYCETOPHILIDAE REARED
Pleurotus ostreatus	Oyster mushroom	Oct., 1915	Calif. Redwood Park	Mycetophila maculosa n. sp. Johannseni aurei n. s. Mycetophila alata n. s. Mycetophila mutica Loew Allodia dentica n. s.
Polyporus sulphureus	Sulphur-colored mushroom	Oct., 1915	Calif. Redwood Park	Mycetophila permata n. s. Mycetophila alata n. s. Mycetophila mutica Loew Allodia dentica n. s.
Armellaria mellea	Honey mushroom	Oct., 1915	Stanford Univ. vicinity	Mycetophila punctata Meigen
Pleurotus Subsapidus	Sapid mushroom	Dec., 1915	Stanford Univ. vicinity	Mycetophila maculosa n. s. Mycetophila punctata Meigen
Hypholoma fasaculare		Jan., 1916	Stanford Univ. vicinity	No insects
Hypholoma appendiculata	Appendiculate mushroom	Jan., 1916	Stanford Univ. vicinity	Dipteron
Hydrocybe?		Jan., 1916	Stanford Univ. vicinity	Mycetophila punctata Meigen Exechia sp.
Boletus granulatus	Granulated mushroom	Jan. & Feb., 1916	Stanford Univ. vicinity	Mycetophila punctata Meigen
Amanita muscaria	Fly mushroom	Jan., 1916	Milbrae	Mycetophila punctata Meigen
Russula?		Jan., 1916	Stanford Univ.	Mycetophila punctata Meigen
Tricholoma personatum	Masked mushroom	Jan., 1916	Stanford Univ.	Boletophila hybrida Meigen
Cortinarius?		Jan., 1916	Stanford Univ.	Boletophila hybrida Meigen
Agaricus?		Jan., 1916	Stanford Univ.	Dipteron
Clitocybe?		Jan. & Feb., 1916		Exechia sp. Meigen Mycetophila punctata Meigen

FUNGUS	COMMON NAME	DATE	LOCALITY	MYCETOPHILIDAE REARED
Locellina stercoraria		Feb., 1916	Stanford Univ.	Exechia sp. Meigen Mycetophila punctata Meigen
Lactaria insulsa	Pepper mushroom	Feb., 1916	Stanford Univ.	Mycetophila mutica Loew
Paxillus?		Feb., 1916	Stanford Univ.	Mycetophila punctata Meigen
Coprinus comatus	Shaggy maid	Mar., 1916	Stanford Univ.	Mycetophila punctata Meigen
Coprinus atramentarius	The Inky mushroom	Mar., 1916	Stanford Univ.	No insects
Stropharia semigloboides		Mar., 1916	Stanford Univ.	Mycetophila punctata Meigen
Helvella?		Mar., 1916	Stanford Univ.	No insects

The most abundant and most common Mycetophilid species found during the season was Mycetophila punctata Meigen. The eggs of this species were collected from between the gills of a Hydrocybe. (?) They were small, white, oval bodies, lying singly between the gills. Several of these were individually isolated in small vials with a portion of food. These eggs hatched in from twenty-four to forty-eight hours.

The larvae fed in the fleshy portion of the fungus, and passing quickly through five instars, pupated within six or eight days. Pupation took place within a silken cocoon, usually in the ground, and the adult insect issued within three days.

EXPLANATION OF PLATES.

Plate XXV.

1a, Wing of *Mycetophila maculosa* n. sp.; A, Hypopygium of *Mycetophila maculosa* n. sp., (lateral aspect); 1, dorsal aspect of hypopygium; 2, upper forceps (one side), of hypopygium; 3, lower forceps (one side), of hypopygium; 4, ventral sclerite of hypopygium.

1b, Wing of *Mycetophila permata* n. sp.; B, Hypopygium of *Mycetophila permata* n. sp. (lateral aspect); 5, lower forceps; 6, upper forceps; 7, dorsal sclerite; 8, ventral sclerite.

Plate XXVI.

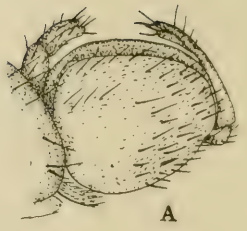
2a, Wing of *Mycetophila alata* n. sp. A, Hypopygium of *Mycetophila alata* n. sp. (lateral aspect); 1, dorsal sclerite; 2, upper forceps; 3, lower forceps.

2b, Wing of *Johannseni aurei* n. sp. (lateral aspect); B, hypopygium of *J aurei* 4, dorsal sclerite; 5, upper forceps; 6, lower forceps.

Plate XXVII.

3a, Wing of *Allodia dentica* n. sp. A, Hypopygium of *Allodia dentica* n. sp. (lateral aspect); 1, dorsal sclerite; 2, upper forceps; 3, lower forceps; 4, ventral sclerite; 5, fore-tarsus (except first tarsal segment); 5a, second tarsal segment.

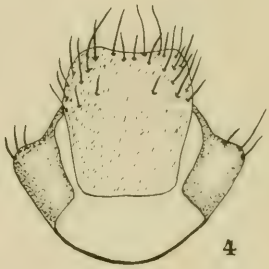

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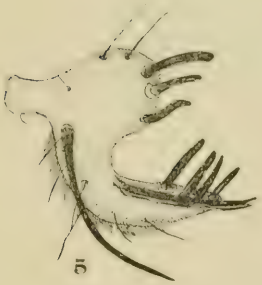

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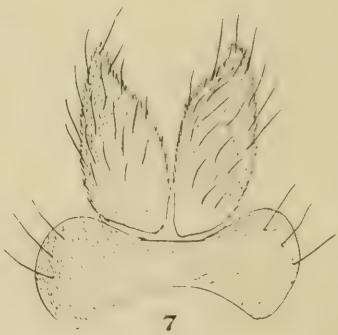

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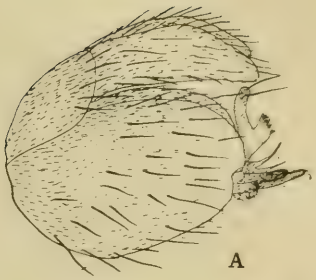

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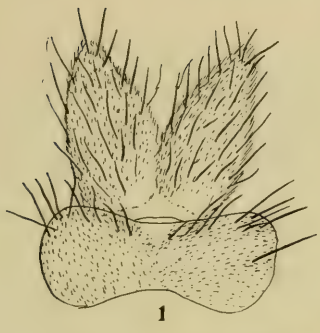

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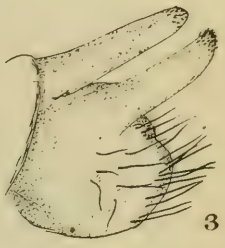
Esther Guthrie.

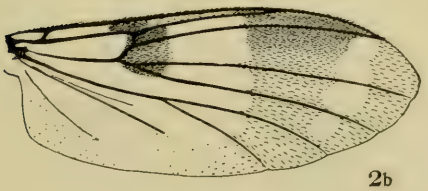


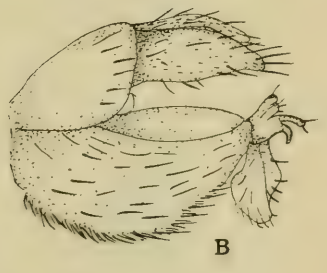


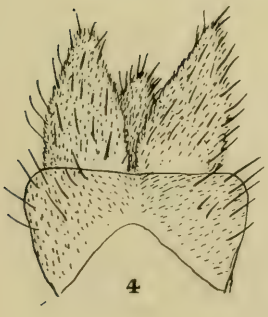


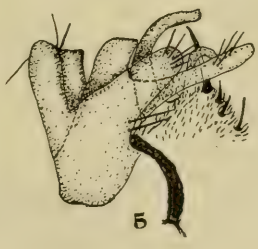


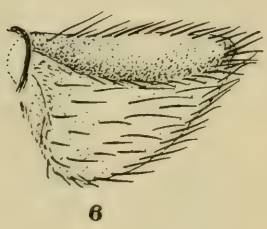






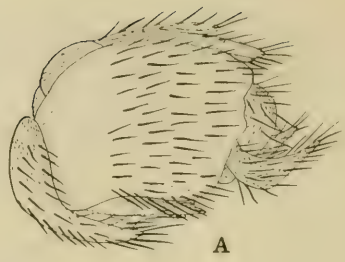






Esther Guthrie.

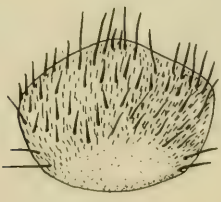














Esther Guthrie

INSECTS IN BURMESE AMBER.

By T. D. A. Cockerell.

The amber from Burma continues to yield interesting insects, those now reported including the largest and finest yet discovered. Mr. Swinhoe has presented the collection to the British Museum, but for obvious reasons it is retained for the present in this country.

Coleoptera.

Acmæodera burmitina sp. nov. (Buprestidæ).

Length 19 mm., width of thorax posteriorly 6 mm.; length of elytra 15 mm., width of an elytron in middle (viewed from above) 3 mm.; original color uncertain, but apparently not metallic; thorax broader than long, the posterior angles sharp, the lateral margins nearly straight, nodulose, the dorsal surface strongly punctured, the punctures about as far apart as the width of one, no striæ on posterior margin; scutellum not evident; elytra punctured basally, but the sculpture well developed in middle, consisting essentially of about nine rows of large elongate punctures, with rows of small dot-like punctures alternating with them; margin of elytra finely nodulose, toward apex definitely denticulate; claws simple. The structure of legs, antennæ and palpi, so far as visible, is shown in the figures.

Burmese amber; from Mr. R. C. J. Swinhoe. This is the beetle referred to in Ann. Ent. Soc. Amer., X, (1917) p. 14, as an Elaterid nearly 20 mm. long. Closer examination shows it to be a Buprestid, agreeing with *Acmaeodera* in the sculpture of thorax and elytra, the dentate margin of elytra posteriorly, and the lack of an evident scutellum. The sharp salient posterior angles of thorax are peculiar, and give it an Elateriform appearance. The insect is not evidently hairy. The one antenna visible is incomplete, but what there is agrees fairly well with *Acmaeodera*. Mr. J. A. Hyslop, to whom I sent a rough sketch, suggests that the insect may fall in the common oriental genus *Chrysodema*. I have no *Chrysodema* for comparison, and leave the species in *Acmaeodera*, since it appears to agree sufficiently with that cosmopolitan genus. Two species of *Acmaeodera* occur in the Miocene of Florissant, and two others in the Miocene of Baden, but none in Baltic amber. *A. burmitina* is in the same slab of amber as the types of *Dermestes larvalis* and *Apenesia electriphila*. The same slab also contains two species of Elateridæ.

Eurygenius wickhami sp. nov. (Pedilidæ).

Length about 5.5 mm., entirely rufotestaceous; eyes extremely large, apparently not emarginate; mandibles very large, prominent, the outer margin very convex; maxillary palpi large, the last joint elongate, subtriangular; antennæ 11-jointed, first joint thickened apically, second much shorter than third, fourth longer than third, eleventh longer than tenth, but not so long as ninth and tenth together; thorax subcircular, glabrous, the margin finely ciliate, the sculpture

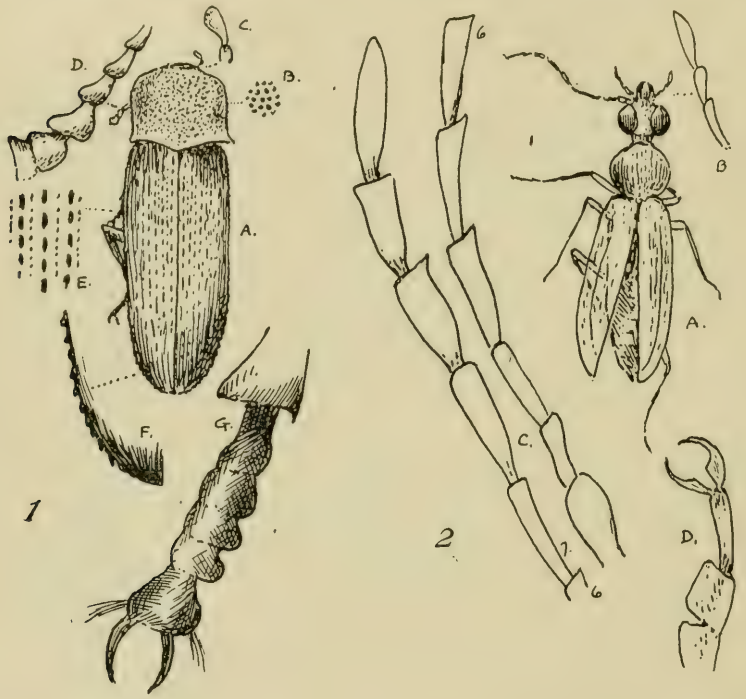


Fig. 1. Acmaeodera burmitina. G—middle leg.
Fig. 2. Eurygenius wickhami. B—Maxillary palpus; C—Antenna; D—End of anterior leg.

consisting of irregular longitudinal grooves; elytra reaching to end of abdomen, and grooved much as thorax, humeri prominent; legs slender, tibial spurs short, tibiæ with much short hair on apical part; claws simple, but expanded basally, with a distinct inner angle. The following measurements are in microns: length of last joint of maxillary palpus, 270; antennal joints, length, (2) 160, (3) 240, (4) 304, (9) 256, (10) 240, (11) 320; length of anterior tibia, 930; middle tibia, 1200; hind tibia, 1600.

Burmese amber; from Mr. R. C. J. Swinhoe. In the same slab as the type of *Acmaeodera burmitina*, and about 8 mm. from it. It is named after Professor Wickham, who has done so much to elucidate the fossil Coleoptera, and gave me valuable advice concerning this specimen. I at first took this insect for a new genus of Oedemeridæ, not noticing the short but evident neck.* It may go in *Eurygenius* as interpreted in the broader sense, though it may hereafter be treated as the type of a distinct genus. It quite closely resembles *E. fragilicornis* Champion from the Seychelles, differing however by the prominent mandibles, relatively slender last joint of palpus, more globose thorax and sculpture of elytra. When Casey discussed the Eurygeniinæ (Eurygeniini, Casey) in 1895, he remarked that they were wholly confined to the new world. Since that time the genus has been found scattered over the eastern hemisphere, *E. niponicus* Lewis coming from Japan, *E. africanus* Kolbe and *E. nigricolor* Pic from the African continent, *E. hovanus* and *E. griseopubens* of Fairmaire, from Madagascar, *E. abdominalis* Pic from Bengal, and *E. fragilicornis* and *E. convexicollis* of Champion from the Seychelles. Reitter recognized a *Pedilus* in Baltic amber.

Elater (sens. latiss.) **burmitinus** sp. n. (Elateridæ).

Length about 11 mm., elytra 7.7 mm.; narrow, width at base of elytra about 3 mm.; thorax finely punctured, the posterior corners sharp, obliquely truncate (see Figure); elytra finely hairy, obtuse at apex, surface with eight simple parallel striæ, between which are numerous very minute piliferous punctures. The color is uniform black.

Burmese amber, from Mr. R. C. J. Swinhoe. Certainly not a species of the true genus *Elater*, but I am unable to refer it to a modern genus with any assurance, the under side and appendages being invisible. It is in a slab, 8 mm. from the type of *Hodotermes tristis*.

*Say described a member of this group as *Oedemera vestita*.

DIPTERA.

Burmacrocera new genus (Mycetophilidæ).

Closely allied to Macrocera, with which the venation nearly agrees, but there is no cross-vein between subcosta and radius, Cu_2 is not bent, the subcosta is longer, and the anal fails before the margin. Second antennal joint cylindrical, not globose; antennæ 16-jointed, very slender, but not nearly so long as the wings. Legs very long and slender, so far as the fragments preserved indicate; tibial spurs very small, claws minute. Thorax with coarse bristles; abdomen slender, petiolate basally; eyes (male) extremely large, covering most of head, the facets elevated, low-conical. Type the following.

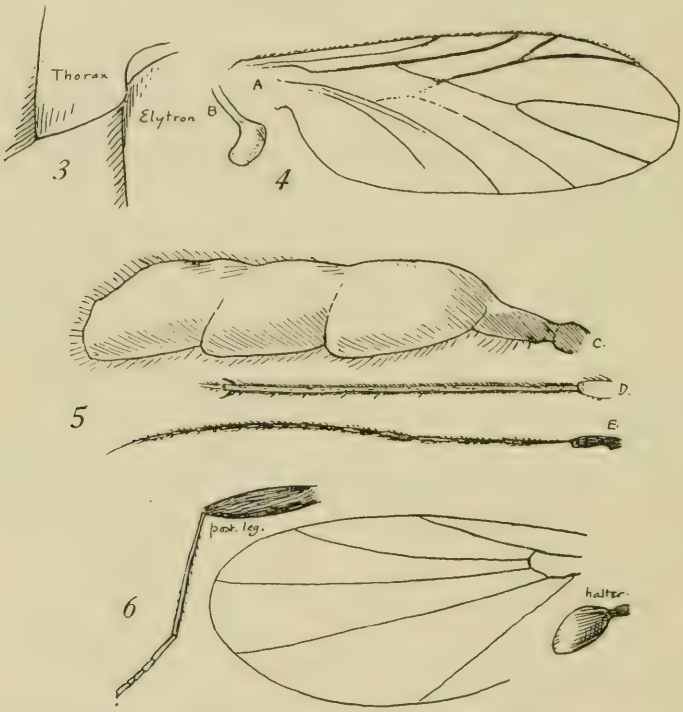


Fig. 3. Elater burmitinus. Posterior angle of thorax.
Fig. 4. Burmacrocera petiolata. Wing. B—Halter.
Fig. 5. Burmacrocera petiolata. C—Abdomen. D—Tibia. E—Antenna.
Fig. 6. Burmitempis halteralis.

Burmacrocera petiolata sp. n.

Male: Black, the wings clear, without spots, veins testaceous; thorax with long hair; abdomen of uncertain length, the apical part lacking in the type; a hind leg (presumably) occurs as a separated fragment, with the apex of the femur, and all the tibia and tarsus; the

tibia and tarsus have short hairs, and short spines at intervals. The following measurements are in microns: Length of wing about 2000; length of cell in fork of media, 800; length of radial sector beyond origin of upper branch, 624; length of antenna, 1200; third antennal joint, 160, sixteenth 80; length of abdomen as far as preserved (see Figure), 1120; hind tibia, 1120; joints of hind tarsus, (1) 608, (2) 224, (3) 160, (4) 88, (5) 96. The thorax is shriveled and distorted in the type.

Burmese amber, from R. C. J. Swinhoe. In outer slab cut from same lump as slab containing the type of *Acmaeodera burmitina* etc., about 10 mm. from the angular corner.

This remarkable fly is evidently allied to *Macrocera*, a genus which occurs in the modern fauna, and also in diverse forms in Baltic amber. The venation is very similar to that of *Palaeoplatyura*, which Johannsen regards as the most primitive in the Mycetophilidæ, but there is absolutely no radio-medial cross vein, and the strongly setose thorax also disagrees with that genus.

Trichoptera.

Plecophlebus new genus. (Odontoceridæ?)

Small species with anterior wings moderately broad, obtuse apically, not densely hairy. Subcosta rather short, not connected with radius; radius deflected downward toward the end, thence curving and eventually meeting the sector at right angles, but before that emitting three branches to costa; sector enclosing a long discoidal cell; upper branch of sector emitting at end two branches directed obliquely upward to apicocostal margin, and also with a cross-vein to second branch, thus enclosing an elongate cell, the base of which rests on the discoidal; third branch of sector (R_5) simple, arising from lower apical corner of discoidal cell; no chitinous dark dot in third apical cell; anterior branch of media not forked; median cell present, elongated; M_3 and M_4 separating beyond end of median cell; structure of cubital and anal veins not ascertainable.

Plecophlebus nebulosus sp. n.

Anterior wing about 6 mm. long, hyaline, with suffused brown spots as shown in Figure.

Burmese amber, from R. C. J. Swinhoe. I had determined this as a new genus, and on submitting a sketch to Dr. N. Banks, he kindly informed me that no genus with such characters was known to him. Dr. Banks pointed out certain resemblances in the upper part of the wing to the Odontoceridæ, and it is to be remarked that the Odontocerid genera *Electrocerum* and *Marilia*, which occur in Baltic amber, have the

radius ending in the sector. In the case of *Plecophlebus* it is not certain that the apparent end of the radius is not a cross vein, the last branch to costa being the true end of the vein. Unfortunately the head of *Plecophlebus* is lost, and the fragments of legs and other parts appear to present no salient characters. Provisionally the genus is referred to the Odontoceridæ, but Dr. Banks notes also a certain resemblance to the Oestropsychids. The character of the venation of the costoapical field will in any case distinguish it from previously known forms.

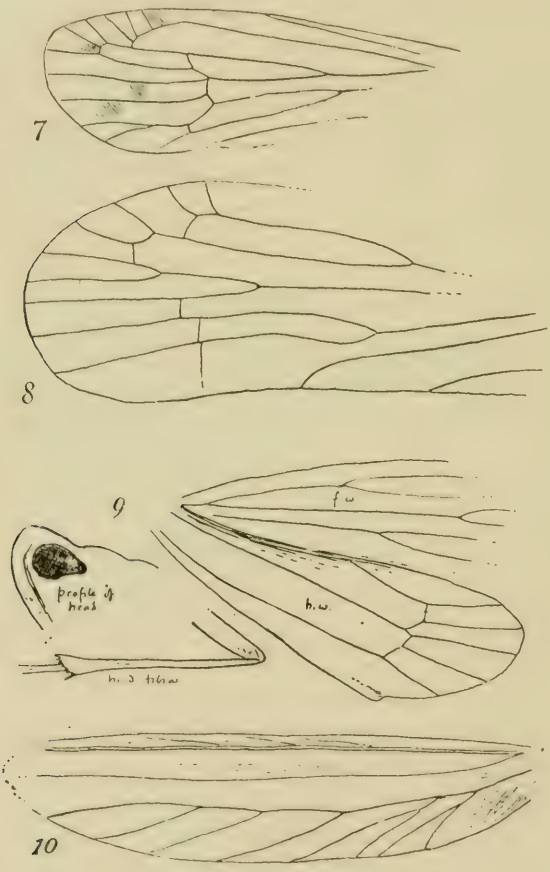


Fig. 7. Plecophlebus nebulosus. Anterior wing.
Fig. 8. Liburnia burmitina. Elytron.
Fig. 9. Liburnia burmitina.
Fig. 10. Hodotermes tristis.

ISOPTERA.

Hodotermes tristis sp. n.

Wing about 4.3 mm. long, dusky grey, the veins distinct. Radius thick (appearing as two fine parallel lines), very close to costa, giving off an uncertain number of delicate branches above; media apparently simple (apex of wing not visible), about midway between radius and cubitus; cubitus with five oblique branches below, the first two soon bifurcating. There is apparently no subcosta.

Burmese amber, from R. C. J. Swinhoe; in a slab cut from the same lump as that containing the type of *Acmaeodera burmitina*, and with the apex of the wing reaching the edge of the slab, where it is 4 mm. thick, about 3 mm. from a broken ferrugious blattid tegmen and 8 mm. from an elaterid beetle. I at first thought this might be a *Termes*, as the superior branches of the radius are delicate and indistinct, but they are certainly present. The remoteness of the media from the radius readily distinguishes it from *Calotermes*. The group Termitinæ doubtless arose through the approximation of the radius to the costa and consequent loss of branches; so the present insect may be considered to represent a development in that direction.

HOMOPTERA.

Liburnia (s. lat.) **burmitina** sp. n.

Length of body about 4.2 mm., to tip of closed elytra probably about 5.7 mm.; dark brown; elytra pale testaceous, without markings; vertex obtuse; frons with very distinct lateral carinæ; tibial spurs very short, about equal (on hind tibia) to width of tibia at apex; apical margin of tibia finely dentate; tarsal joints with apical margins provided with numerous minute straight blunt spines; eyes pyriform, scarcely emarginate below. Venation as shown in Figures. Scutellum not visible.

Burmese amber, from R. C. J. Swinhoe; in a slab cut from the same lump as that containing the type of *Acmaeodera burmitina*, 13 mm. from the margin. The slab is the one having one side rough. Very close to the *Liburnia* is a specimen of *Burmitempis halteralis* Ckll., from which I have made a new figure.

This insect is evidently not a *Liburnia* in the restricted sense. It appears to fall in the vicinity of *Copicerus*, but it has the more primitive, separate anal veins. It should possibly be regarded as the type of an extinct genus, but if so, the separation should be made by one more familiar with Delphacine genera.

PARTHENOGENESIS IN THE PEAR-SLUG SAW-FLY.

By H. E. Ewing, Iowa State College, Ames, Iowa.

Introductory.

But few of our economic insects have been studied more than the common pear-slug or cherry-slug saw-fly, *Caliroa cerasi* Linn., yet concerning some points in its biology and life history we are as yet in doubt. Parthenogenesis, known to occur in some of the saw flies, has been suspected in the case of this species, but does not appear to have been sufficiently proved. Mr. R. L. Webster, in his bulletin on this pest* presents a good account of its biology and life history, but in regard to parthenogenesis (complete and successful) he states that it had not been sufficiently proved, yet some important observations were made which are mentioned in this paper.

Rarity of the Males.

Males of the pear-slug saw-fly have been described, and were at one time supposed to be fairly common. Mr. Webster, however, noticed early in his work with the species the apparent absence of the males around Ames, Iowa. On page 181 of his bulletin he states: "We have collected and examined large numbers of saw-flies, but have never found a male." He also wrote to Mr. S. A. Rohwer, of the U. S. National Museum in regard to the rarity of the males. Mr. Rohwer examined the collection of the museum, and reported that there were no males there, either from Europe or from America. While working at the Iowa Station in 1911, and while at the Oregon Station, 1911-14, I had occasion to examine hundreds of these saw-flies but never found a male. It appears then that if males exist in this country, they must be very rare in certain localities.

Caliroa cerasi differs from many of the saw-flies in respect to the numerical ratios of the sexes, for in some of the species the males are present in abundance, and mate normally with the females. This was shown to be the case with the cherry

*Webster, R. L. The Pear-slug. Bul. No. 130, Iowa Agric. Exp. Sta. (1912).

and hawthorn saw-fly leaf-miner, *Profenusa collaris* MacGillivray, by Parrott and Fulton.† In this regard they give the following: "Out of doors the females appeared in larger numbers at a somewhat earlier period than the males, but judging from collections taken at irregular intervals it does not appear that marked numerical differences existed between the sexes. To all appearances the adults copulated freely. In one breeding cage, containing no males, two females made their appearance, and these were isolated and supplied with cherry twigs to induce oviposition. This they did, and five days later three eggs hatched. This experience suggests that fertilization is not absolutely necessary for the development of the eggs and also indicates that parthenogenesis may occur, although it is perhaps not an important factor in the life of the species."

Experiments at the Iowa Station.

Webster in his bulletin states that parthenogenesis probably occurs in the pear-slug saw-fly, but that it had not been satisfactorily proved. However, he showed that virgin females would deposit eggs and that these eggs would hatch; yet none of the larvæ hatching from parthenogenetic eggs was reared to maturity. In regard to these experiments, Webster states: "Both Mr. Ness and Mr. McCall confined virgin female saw-flies in insectary cages and obtained eggs from them. Some of these eggs hatched, but the larvæ were weak and in no case did they live more than a few days. None reached the second stage." These experiments seemed to show that there was not a complete normal parthenogenesis like that which exists in the plant lice, or in fact in the case of some of the other species of saw-flies, but a type similar to that known to exist in the silk worm, where only a few unfertilized eggs hatch, and the issuing larvæ never reach maturity.

Breeding Experiments Carried on by the Writer.

During the month of May, 1913, while rearing the black cherry aphis, *Myzus cerasi* Fab., as food for Coccinellidæ, the life histories of which I was studying, three females of *Caliroa cerasi* emerged in the aphid breeding cages. These breeding

†Parrott, P. J., and Fulton, B. B. The Cherry and Hawthorn Sawfly Leaf-Miner, Bul. No. 411, New York Agric. Exp. Sta. (1915).

cages were quite large, being about three feet high and over three feet in diameter, and each was placed over a young cherry tree that had been cut back so as to be enclosed by the cage. They were out-of-door cages without bottoms, so that any insects emerging from the soil would be caught. On June 6th I observed that two females had emerged in one of the cages which I designated as cage A, and in another, one female saw-fly had emerged. This second cage was designated as cage B. These virgin females began to oviposit almost at once, and by June 15, in cage A, I noted several eggs and six young larvæ, and in cage B another female had emerged, and a few eggs were observed but no young slugs. By July 5, the females had died in cage A, many growing slugs were present but no pupæ. These larvæ continued to grow, and feed in a normal manner, and then to pupate.

On July 31 I noticed the first adult of the second generation (F_1) had emerged. It was very active, and was moving about the upper side of the cage. From now on adults from the parthenogenetic eggs of the first generation females continued to emerge rapidly.

In all, 34 adult individuals were obtained from the parthenogenetic eggs of the two females in cage A. All of them were females, and all were healthy, active and vigorous.

As fast as these females emerged they were isolated and each placed in a gauze-bag breeding cage, which was placed around the end of a cherry branch. These gauze bags were of sufficient size to allow the females considerable freedom, and were placed over the branches several weeks earlier after every leaf had been carefully examined for foreign eggs. This was a precaution against contamination, the bags excluding all the other saw-flies in the orchard.

Some of the data obtained for the rearing of these parthenogenetic individuals are here presented in tabular form.

TABLE I.*

Individual	July 31	Aug. 1	Aug. 3	Aug. 5	Aug. 7	Aug. 8	Aug. 9	Aug. 10	Aug. 12	Aug. 18	Aug. 21	Aug. 22	Aug. 23
1	em.	br.bag					eggs l. dead						
2		em. br. bag							eggs l. dead				
3			em. br. bag						eggs l. dead				
4			em. br. bag						eggs l. alive				
5				em. br. bag					eggs l. alive				
6				em. br. bag					eggs l. dead				
7				em. br. bag						eggs l. dead			
8				em br. bag						eggs l. dead			
9					em. br. bag					eggs l. dead			
10					em. br. bag					eggs l. dead			
11					em. br. bag						eggs l. dead		
12					em. br. bag						eggs l. dead		
13					em. br. bag						eggs l. dead		
14					em. br. bag						eggs l. dead		
15						em. br. bag					eggs l. dead		
16						em. br. bag					eggs l. dead		
17						em. br. bag					eggs l. dead		
18						em. br. bag					eggs l. ad. lost		
19						em. br. bag					eggs l. dead		
20						em. br. bag						eggs. l. dead	
21							em. br. bag					eggs l. dead	
22							em. br. bag					eggs l. ad. lost	
23							em. br. bag					eggs l. dead	
24							em.	br. bag					eggs l. dead
25							em.	br. bag					eggs l. dead
26								em. br. bag					eggs l. dead
27									em. br. bag				eggs l. dead
28									em. br. bag				eggs l. dead
29									em. br. bag				eggs l. ad. lost
30									em. br. bag				eggs l. dead
31									em. br. bag				eggs l. dead
32									em. br. bag				eggs l. dead

*The abbreviations used in this table are explained as follows: em.—adult emerged; br. bag—placed in breeding bag; eggs l.—eggs laid; ad. lost—adult lost.

From this table we observe that all of the 32 virgin females that were reared from the eggs of the 2 first-generation virgin females laid eggs. Since the breeding cages used up to this time were out-of-door cages these observations give us some insight into the seasonal history of the species. The first adult of the second generation to emerge came out on July 31, the last on August 12. Eggs of the second generation adults were first observed August 9. The first record of a death of the second generation adult was August 9. By August 23 all of the adults of the second generation were dead. The period of longevity appears to be quite short for these second generation adults.

The progeny of four of these second generation adults was saved, and reared in four separate breeding cages. Some of the data for these four experiments are given in tabular form in the following table.

TABLE II.

Offspring Of Female	Larvae Isolated	When Isolated	Notes For Oct. 5	Notes For Feb. 16	Notes For June 28
No. 2	30	Sept. 11	In soil		
No. 8	30	Sept. 15	In soil	3 pupae found 2 alive	1 dead adult on top of soil. 3 dead larvae in earthern cells 3 dead pupae in earthen cells. 7 dead adults in earthen cells.
No. 14	33	Sept. 17	In soil		Empty earthen cell observed.
No. 25	16	Sept. 27	In soil		3 dead larvae in earthen cells. 3 dead pupae in earthen cells. 3 dead adults in earthen cells.

The results from these four breeding cages were surprising. Of the large number of larvæ obtained (109) during the fall only a single adult emerged the following spring. Examinations during the winter showed that most of the larvæ had pupated and were alive. Later on I made a very thorough search in the soil for predaceous enemies, but found none that I suspected of preying on the larvæ or pupæ. In fact the final examination on June 28 showed that the earthen cells were intact. Of the 23 earthen cells found on this day, 10 contained the mature dead saw-flies. They had passed through their transformations in good shape, but for some reason did not emerge from their earthen cells.

Can it be that parthenogenesis when continued into the second generation descendants causes a great diminution in the vitality of the race?

Observations in the orchard where the first virgin females were obtained showed that the conditions there were similar to those of my experiments. During the first year there were large numbers of the first generation females present, but I did not observe a single male, hence infer that practically all of the eggs laid were unfertilized. These females laid an enormous number of eggs, and apparently almost all of them hatched, for seldom have I seen cherry trees more heavily infested than were these trees during the summer of 1913. The injury was so great that several of the younger trees were killed outright—something unusual in the case of saw-fly infestation. Yet in this same orchard the following spring, scarcely a saw-fly emerged. On June 7, I examined the orchard thoroughly, and did not find an adult or a single egg. It was June 20 before I found eggs, and then only a few of them. The slugs that developed in this orchard in 1913 were very few, and were of no importance from an economic standpoint, in fact most of the trees were absolutely free from them.

Could it be that climatic conditions killed the saw-flies in this orchard and in my cages? During the spring of 1913 we had a very warm spell in March, and later a cold snap. Could this warm spell have so hurried the development of the saw-flies that they were later killed by the cold? I think not, for in other places in the same vicinity the saw-flies came out in abundance. One orchard, only a few miles away, was badly infested and injured the same spring. Could the saw-flies have been killed by a fungous disease? None whatever was detected. Even the bodies of dead individuals were usually free from fungi. Could it be that the ground was so hard during the emerging period that the adults could not make their way out? I hardly think so. At first I suspected this as being the reason, but after keeping the ground soft in two of my breeding cages for many days, I did not get a single saw-fly to emerge. Besides the thorough examination of the earthen cells showed that the adults did not even get out of them.

It appears then that we must look elsewhere in order to find the causes for the non-emergence of these second generation parthenogenetic adults. Judging from the facts collected during my investigations of this species, I am inclined to the opinion that parthenogenesis while normal and completely advantageous for the species in the spring parthenogenetic

generation, when continued into the second generation causes a great diminution in the vigor of the individuals. Some of these second generation individuals die in the larval stage; some, as shown in my experiments, in the pupal stage; and many of them in the adult stage inside of the earthen pupal cases.

Summary.

1. The males of our common pear- or cherry-slug saw-fly must be very rare in certain parts of our country. The examination of several hundreds of individuals obtained at various times during the late spring and summer for three seasons at Ames, Iowa, and for two seasons at Corvallis, Oregon, failed to reveal a single male.

2. The species is parthenogenetic, and successfully so for the offspring of the spring brood of females.

3. The eggs deposited by spring-brood virgin females hatch, and produce normal vigorous larvæ. These feed normally, later pupate and finally produce adults.

4. Unfertilized eggs produce females only.

5. Parthenogenesis when continued for the offspring of the second or summer brood of adults, gave larvæ, a considerable percentage of which failed to pupate, a considerable percentage successfully pupated, but did not transform into the adult stage, and a very large percentage transformed into adult stage, but did not emerge from the enclosing earthen cells.

6. Only a single adult was reared from 109 of the second generation parthenogenetic larvæ.

7. An orchard which was heavily infested with spring-brood females, and in which no males were observed, produced an enormous number of second generation females, which produced in turn an increasing number of second brood larvæ, causing injury so serious as to kill outright several cherry trees of the orchard and to seriously injure all of the trees. From this enormous second brood of larvæ only a very few adults emerged the following spring.

8. I am unable to account for the failure of these second brood larvæ to produce active adults unless it be on account of a lack of vigor due to the absence of fertilization for this brood, yet it is possible that this failure was due to other causes.

A PHYLOGENETIC STUDY OF THE LARVAL AND ADULT HEAD IN NEUROPTERA, MECOPTERA, DIPTERA, AND TRICHOPTERA.*

By G. C. Crampton, Ph. D.

Since practically all of the recent attempts to trace the phylogeny of insects have been based upon the study of the wing veins, which are extremely variable features within the same order, or even family, of insects, it has seemed advisable to examine other less variable structures, and those from widely different parts of the body, in order to ascertain if such a study would confirm or disprove the conclusions reached from a study of the wing veins alone. The present paper is therefore offered as one of a series in which the various structures which appear to be the most useful for a phylogenetic study, have been compared in the Neuroptera, Mecoptera, Diptera and Trichoptera. Many of the accompanying rough sketches were made from material kindly loaned to me by Dr. N. K. Banks, to whom I am deeply indebted for many valuable suggestions, and for the privilege of examining the specimens in his unusually extensive collection of Neuroptera, Mecoptera, and Trichoptera. I am also greatly indebted to Dr. C. W. Johnson for the identification of the Diptera used in the preparation of this paper.

It is customary to speak of this or that single type as the ancestral one for a large group of insects, but I think that this is a mistaken conception, since a study of the ancestral groups (or rather, those which have departed but little from the condition characteristic of the ancestors of other insects) would indicate that the ancestral forms frequently differed quite markedly among themselves, exhibiting *several* developmental tendencies (instead of merely one type) which frequently manifest themselves in the evolutionary series of the forms derived from them. As an illustration of this view, I would call attention to the "short-headed" series of Neuroptera, Mecoptera, and Diptera shown in Figures 1, 2 and 3, and the "long-headed" series of the same groups of insects shown in Figures 4, 5 and 6. These

*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass.

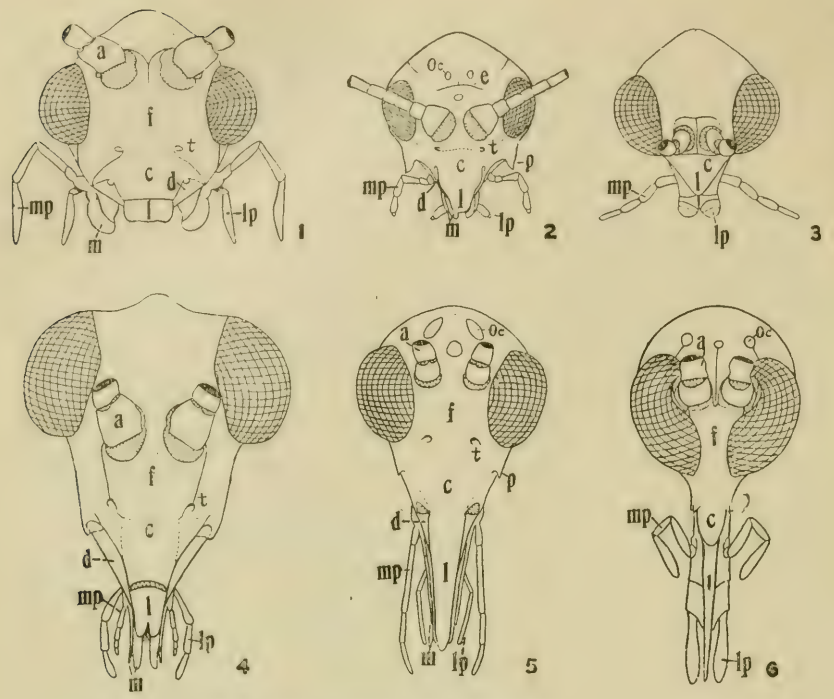


Fig. 1. Head of the Neuropteron *Hemerobius.*
Fig. 2. Head of the Mecopteron *Panorpodes.*
Fig. 3. Head of the Dipteron *Erioptera armata,* O. S.
Fig. 4. Head of the Neuropteron *Nemoptera.*
Fig. 5. Head of the Mecopteron *Bittacus.*
Fig. 6. Head of the Dipteron *Asyndulum montanum* Roeder.

In all cases, excepting figures 12 and 13, the head is drawn in frontal view. In some figures only basal segments of antennæ are drawn. The areas of cross-hatching denote the compound eyes.

ABBREVIATIONS.

a—Antenna, or basal segments of antenna.
ac—Anteclypeus.
c—Clypeus, or clypeal region.
d—Mandible.
e—Epicranial suture.
f—Frontal region.
l—Labrum, or labral region.
lp—Labial palpus, or terminal portion of labium.
m—Maxilla.
mp—Maxillary palpus.
o—Occipital region.
oc—Ocelli.
p—Genal process.
t—Tentorial or frontal pits.
x—Plical process, or point of attachment of cervical fold.
y—Line of attachment of cervical fold or plica.

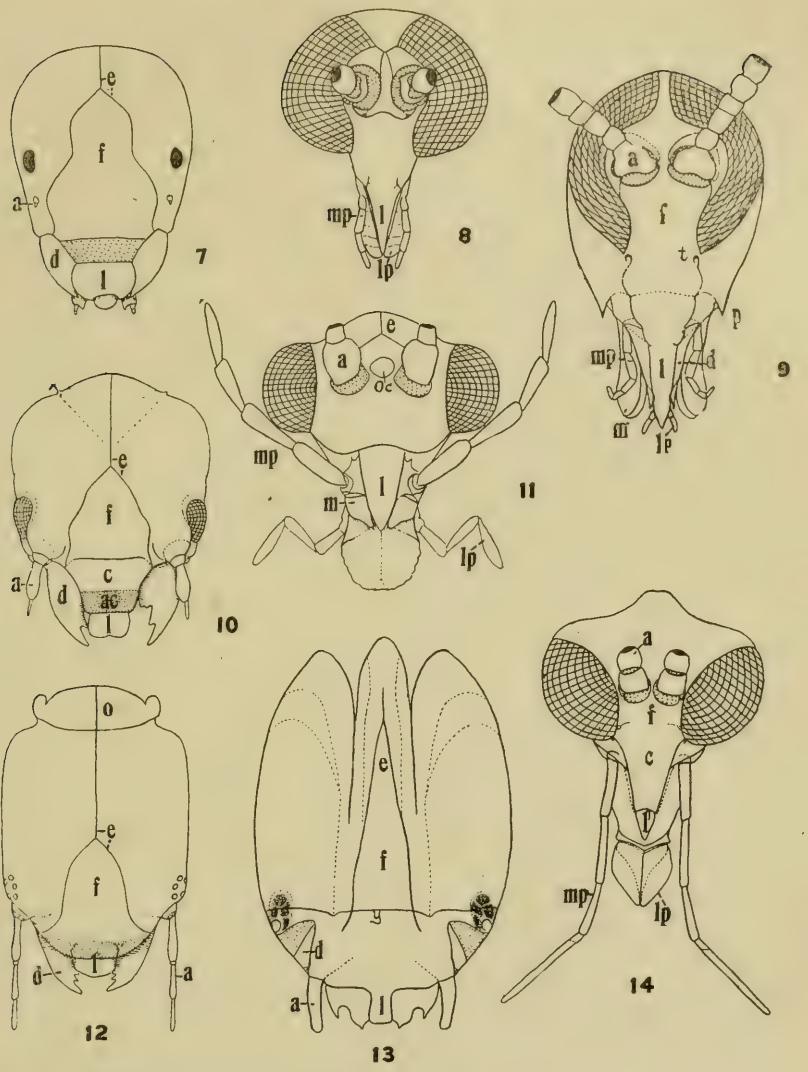


Fig. 7. Head of a larval Trichopteron.
Fig. 8. Head of the Dipteron *Heteromyia* (Ceratopogon) *trivialis*, Loew.
Fig. 9. Head of the Mecopteron *Merope tuber* (male).
Fig. 10. Head of a larval *Panorpa* (Mecopteron).
Fig. 11. Head of the Trichopteron *Neuronia*.
Fig. 12. Head of a larval *Raphidia* (Neuropteron).
Fig. 13. Head of a larval Tipulid.
Fig. 14. Head of the Dipteron *Bittacomorpha* (based upon the species *clavipes* and another *Bittacomorpha*).

series show very clearly that in the Neuroptera (among which are found certain forms which have departed but little from the ancestral condition of the Mecoptera) instead of merely one type, there are at least two developmental tendencies, the one leading to a retention of a shorter type of head such as that of the Neuropteron shown in Fig. 1, while the other leads to the formation of a more elongate type of head, such as that of the Neuropteron shown in Fig. 4. These two tendencies are carried over, or re-appear, in the Mecoptera, which are descended from Neuropteron-like forebears. Thus the short-headed type is retained in such Mecoptera as that shown in Fig. 2 (which, however, exhibits a slight tendency toward a narrowing and lengthening of the lower portion of the head), while the tendency toward the formation of the elongate type of head appears again in such Mecoptera as that shown in Fig. 5. Similarly, in the Diptera, which in turn are derived from Mecopteron-like forebears, the same two tendencies reassert themselves, some of the Diptera having retained the short-headed type, as shown in Fig. 3, while other Diptera, such as the one shown in Fig. 6, have developed the elongate type of head.

It might be argued that a similar mode of life, or similar "environmental" conditions might cause a marked similarity in outline in the heads of the insects in question, and that this similarity is therefore due to a convergence—or rather to a parallelism of development. However, the marked morphological similarity in a series of structures taken from widely separated parts of the body (e. g. mouthparts, thoracic sclerites, legs, terminal abdominal structures, etc.) and the marked resemblance which extends even to the more minute details, and in parts which are not much used, or are not of vital importance to the organism, would preclude the possibility of a mere parallelism of development—which might possibly be the case if we were dealing with a single set of structures alone; but to argue that a parallelism of development has brought about the similarity in structure between all of these parts of the body in the series, is demanding too much of chance and the "law of probability."

While claiming that the series of insects represented in Figs. 1, 2 and 3 and the series represented in Figs. 4, 5 and 6, to all intents and purposes serve to illustrate what has actually

happened in the evolution of the head region of certain Diptera, I would not imply that recent Diptera are descended from recent Mecoptera, or that living Mecoptera are descended from living Neuroptera. On the other hand, it is quite true that living Neuroptera, Mecoptera, and Diptera have travelled together along the same developmental "road," so to speak, in following out certain evolutionary tendencies. At some point along the road, the Neuroptera branched off to follow their own path of specialization, but some of them wandered but a short distance from the main line, and have remained as little changed as certain of the fossil forms which fell by the wayside at an early date. These "conservative" individuals have preserved many features characteristic of the ancestors of the Mecoptera and Diptera who continued together for a greater distance along the road of evolution, before the Mecoptera in turn branched off to follow their own path of specialization. So too, among the Mecoptera certain individuals wandered but a short distance from the main line, and have preserved many features characteristic of the ancestors of the Diptera, and the same process was repeated when the Dipteron-like ancestors of the fleas gave rise to the Siphonaptera. The study of these "conservative" forms among living insects is quite as instructive as the study of fossil forms, and has the additional advantage of enabling one to examine the minute details not preserved in the fragmentary fossil remains, and to take into account the biological habits, etc., which are of considerable importance in an attempt to determine the relationships of the different groups of insects.

In the head region of nearly all adult Mecoptera, there is a well marked tendency toward the formation of a "genal process" or protuberance of the lower portion of the genæ ("p" of Figs. 2, 5 and 9), and it is rather strange that such a widespread tendency in the Mecoptera should not reappear in the Diptera—although the process of the genal region labeled "p" in the Dipteron shown in Fig. 6 may be homologous with the genal process of the Mecoptera. In some of the Mecoptera (Fig. 9) there is a tendency for the eyes to extend upward toward the top of the head, and downward toward the mesal line below the antennæ, and the same tendency is evident in the Diptera shown in Figs 8 and 6.

In some Diptera (Fig. 14) the contour of the upper portion of the head is more like that of certain Neuroptera (Fig. 4), while in other Diptera (Figs. 6 and 8) it is more like that of certain Mecoptera (Figs. 5 and 9). On the whole, the basal segments of the antennæ of the Diptera (Figs. 6 and 14, "a") are more like those of the Mecoptera (Fig. 5), and the resemblance between the antennal segments of the Mecopteron *Merope* and those of certain Mycetophilids and other Diptera is very striking, as I am hoping to show in a subsequent paper. In these respects, the Trichopteron shown in Fig. 11 is more like the Neuroptera than it is like the Diptera and in general the statement would hold true, that the Mecoptera approach the Dipteron type far more closely than the Trichoptera do, and are therefore in all probability much more closely related to the Diptera than the Trichoptera are, although the Trichoptera also have carried over certain "ancestral" features from the common ancestral group which gave rise both to them and to the Mecoptera and Diptera, so that they cannot be entirely disregarded in a phylogenetic study of the insects in question.

Although the labial palpi "*lp*" are much larger than the maxillary palpi "*mp*" in the "long-headed" Neuropteron shown in Fig. 4, the maxillary palpi "*mp*" are much longer than the labial palpi "*lp*" in the Neuropteron shown in Fig. 1, and in most Mecoptera (Figs. 2, 5 and 9) and Diptera (Figs. 3 and 14) this is likewise the case, as is also true, to a lesser degree, in the Trichopteron shown in Fig. 11. There is thus apparent in the Mecopteron and Dipteron stocks a marked tendency toward the reduction of the labial palpi, and the glossæ and paraglossæ tend to disappear, although I am not certain that neither paraglossæ nor glossæ are well developed in the Diptera, since Peterson, 1916, who has examined a wide range of Diptera, thinks that glossæ and well developed paraglossæ are to be found in this group. On the other hand, if one examines a specimen of *Bittacus* and *Panorpa*, it is quite evident that the maxillæ (excepting the palpi) are reduced, or have begun to unite with the labium, and that the glossæ and paraglossæ of the labium have almost disappeared, while the labial palpi have become approximated in the median line, thus assuming a condition suspiciously like that exhibited by the Dipteron shown in Fig. 6. A study of the embryological development

of the parts in question is necessary before this point can be definitely determined but the "phylogenetic" evidence would indicate that Peterson's interpretation of some of these structures may need revision. A detailed comparison of the mouthparts, accompanied by drawings of the insects in question, will be published later, as a part of the series dealing with the phylogeny of the Diptera, Mecoptera, etc., so that it is unnecessary here to do more than call attention to the tendency toward an elongation of the mouthparts exhibited by certain Neuroptera (Fig. 4), and developed to a greater extent in certain Mecoptera (Fig. 5), while it is carried to an extreme in the Culicids and other Diptera.

A comparison of the heads of the larvæ under consideration has thus far been rather disappointing, due to the fact that it is necessary to examine a far wider range of forms than is at present available, in order to select those which have preserved the desired characters—and it is largely a matter of chance whether one is so fortunate as to find these or not. I have no Culicid or Chrysopid larvæ at present, but I recall having observed in them a "cervical plica," or fold of the membranous region of the neck, which projects over the head capsule for a short distance and is attached to it at the point labeled "x" in Fig. 10 of a Panorpid larva. In some of the Trichopterous larvæ which I have examined, a similar "cervical plica" is attached to either side of the head capsule, but it is not so well developed in the Trichoptera. It is possible that a further overgrowth of the head capsule by the neck-fold mentioned above, has resulted in the condition exhibited by the Tipulid larva shown in Fig. 13, in which a fold of the neck membrane has grown over the head capsule, to which it is very closely applied, as far forward as the line labeled "y" in Fig. 13.

As far as the head region of the larvæ is concerned, the Diptera seem to be about as similar to the Neuroptera as they are to the Panorpids, and the head of a larval Panorpid is somewhat more "Neuropteron-like" than the head of a larval Trichopteron is. In the case of the adult head, however, the Diptera are closer to the Mecoptera than to the Neuroptera, and also appear to be very much closer to the Mecoptera than to the Trichoptera. In conjunction with the study of such other features as the antennæ, mouthparts, thoracic sclerites, legs,

terminal abdominal structures, etc., a comparative study of the head capsule in the insects in question would indicate that the line of development of the Trichoptera branched off from the common ancestral "Neuropteroid" stem at a point not far distant from the origin of the Mecopteron line of development. The ultimate ancestors of the Diptera were Neuropteron-like (the tendency toward the reduction of the hind wings occurring regularly in such Neuroptera as *Nemoptera*, and occasionally in such forms as *Psectra, etc.*) and they were related to both the ancestral Trichoptera and Mecoptera. The Dipteron line of development, however, has paralleled that of the Mecoptera remarkably closely (more so in fact than any other insects) and since the Mecoptera have "lagged behind," or have not travelled as far along the road to specialization as the Diptera have, they have remained in many respects strikingly like the ancestors of the Diptera, so that a study of their structures will frequently serve to indicate the steps by means of which the more highly modified homologous structures in the Diptera have reached their present state, in following out certain evolutionary tendencies present in both lines of development.

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A more complete list of the articles dealing with the mouthparts and phylogeny of the insects under consideration will be given in articles dealing with these phases of the subject.

A SYNOPSIS OF THE PETIOLATE WASPS OF THE FAMILY EUMENIDÆ (HYMENOPTERA), FOUND IN AMERICA NORTH OF MEXICO.

By Dwight Isely,
Bureau of Entomology, United States Department of Agriculture.

The wasps of the family Eumenidæ with petiolate abdomens, found in America north of Mexico are included in two genera, *Eumenes* Latreille and *Zethus* Fabricius. The following synopsis is based on specimens contained in the U. S. National Museum. Of the genus *Eumenes* the Museum contains 11 of the 13 hitherto described species and has large series of specimens of several of these. Of the genus *Zethus* it contains specimens of all of the five described species, but the number of specimens in all species is comparatively small. In addition to the descriptions of new species included in this paper there are redescriptions of the Say and Haldeman species and of a number of other species which it seemed desirable to compare with their allies.

For the sake of clearness, descriptive terms used in this paper which are not usually used by other hymenopterists or whose usage is not always the same, may be defined as follows:

Length.—The measurement from the front to the apical margin of the second segment of the gaster.

Lateral angles of the clypeus.—The angle produced by the meeting of the apical and lateral margins of the clypeus.

Pronotal lobes.—Lobes which project from either side of the prothorax into the mesoepisternum a short distance below the tegulæ.

Metanotum.—The simple transverse plate which bears the hind wings. This is the **postscutellum** of many authors.

Propodeum.—The tergite of the first abdominal segment which has been fused to the thorax.

Gaster.—The abdominal segments after the constriction separating them from the thorax, that is, all of the abdominal segments except the propodeum.

Petiole.—The first segment of the gaster, or the **first abdominal segment** of many authors. It is not considered advisable to designate the petiole as distinct from the gaster and preceding it, for with the majority of the species of this family there is no petiole.

Apical cordon of the petiole.—The salient margin or rim at the apex of the tergite of the petiole.

Dorsal angle of the second segment of the gaster.—The median dorsal line when viewed laterally forms a more or less distinct angle which ordinarily marks the maximum inflation of the segment.

Lateral angle of the second segment of the gaster.—The lateral lines when viewed dorsally form a more or less distinct angle as does the dorsal line, which ordinarily marks the maximum lateral inflation of the segment.

The writer wishes to thank Mr. S. A. Rohwer for testing the keys to species and for criticisms and suggestions throughout the course of the studies herein presented.

The genera *Eumenes* and *Zethus* are not closely related, yet because of a superficial resemblance they can be conveniently considered together. They may be readily separated from all other wasps of the family Eumenidæ, found in America north of Mexico, by the first segment of the gaster which is petiolate, while in all other genera found within these limits it is sessile or subsessile. In turn these two genera may be separated by the following contrasting characters:

Eumenes.—Mandibles long, and sharp pointed; clypeus as long or longer than wide; head compressed transversely, not dilated behind the eyes, posterior face truncate; thorax quadrate, not strongly contracted anteriorly; prothorax nearly as wide as the head; petiole expanded, or at least not strongly contracted apically; second segment of the gaster sessile or subsessile.

Zethus.—Mandibles short, obliquely truncated; clypeus wider than long; head dilated behind the eyes, posterior face emarginate; thorax strongly contracted before the tegulæ; prothorax much narrower than the head; petiole strongly contracted apically; second segment of the gaster subpetiolate.

Genus *Eumenes* Latrielle.

The genus Eumenes as it is found in America north of Mexico forms a very homogeneous group. The differences of groups of species, however constant they may be, do not justify its division into subgenera, and it is probable that if extralimital species were studied that many of these group differences would disappear. However to facilitate the determination of species, those under consideration may be divided into four species groups, which named after the oldest species in each group are as follows: The *smithii group*, the *crucifera group*, the *fraternus group*, and the *crassicornis group*. All of these except the *crucifera group* would fall into Saussure's division Alpha.

Key to the Species of Eumenes.

1. Dorsum of the petiole impunctate.....*bollii* Cresson
 Dorsum of the petiole distinctly punctate.....2
2. Head flattened dorsally; petiole linear pyriform, without abrupt inflation, ventral aspect of the tergite sparsely punctate.....*brunneus* Isely
 Head convex dorsally; petiole pyriform or campanulate, inflation always more or less abrupt; ventral aspect of the tergite densely and coarsely punctate.....3
3. Sternite of the petiole not distinctly separated from the tergite except near the apex; dorsal line of the second segment of the gaster strongly curved forward before the dorsal angle.....4
 Sternite of the petiole distinctly separated from the tergite by a groove and a carina; the dorsal line before the dorsal angle on the second segment of the gaster not strongly curved forward.....6

4. Punctation on the ventral aspect of the tergite of the petiole extending up to the margin before the apical broadening of the sternite; a transverse brownish band crossing the middle of the dorsal aspect of the second segment of the gaster.....*smithii* Saussure
 Punctation on the ventral aspect of the tergite of the petiole not extending up to the margin, except after the apical broadening of the sternite; a transverse yellowish band, (sometimes interrupted), crossing the middle of the dorsal aspect of the second segment of the gaster.....5
5. A largely brownish wasp.....*belfragei* Cresson
 Brownish, replaced by yellow or golden....*belfragei* subspecies *aureus* Isely
6. Second segment of the gaster depressed (wider than high) or if not distinctly depressed the dorsal angle is surmounted by a boss.....7
 Second segment of the gaster compressed, or if not distinctly so the dorsal angle is without a boss.....10
7. Apical emargination of the clypeus shallow, but angular; second segment of the gaster with the dorsal line after the dorsal angle nearly straight with no broad transverse depression before the apex...*stenogaster* Isely
 Apical emargination of the clypeus rounded; second segment of the gaster with the dorsal line after the dorsal angle recurved and with a broad transverse depression before the apex.....8
8. Second segment of the gaster beyond the lateral angles with the sides parallel, not convergent until near the apex, segment longer than wide. *holliformis* Viereck
 Second segment of the gaster beyond the lateral angles with the sides convergent, not longer than wide.....9
9. Apical cordon of the petiole not prominent, no distinct constriction immediately preceding it; abdomen largely yellow...*crucifera* Provancher
 Apical cordon of the petiole prominent, with distinct constriction immediately preceding it; abdomen largely black.....*sternalis* Isely
10. Antennæ comparatively short and stout, reaching about to the tegulæ; petiole not more than twice as long as wide; sides of the prothorax before the tegulæ concave or contracted.....18
 Antennæ not especially short and stout, as long or nearly as long as the thorax; petiole more than twice as long as wide; prothorax little if ever contracted before the tegulæ.....11
11. Dorsal angle of the second segment of the gaster surmounted by a boss; dorsal line recurved apically.....12
 Dorsal angle of the second segment of the gaster rounded and without a boss; dorsal line not recurved apically.....13
12. Second segment of the gaster with two yellow bands, one of which is interrupted.....*cruciferorum* Viereck
 Second segment of the gaster with three yellow bands, two of which are interrupted dorsally.....*tricinctus* Isely
13. Second segment of the gaster about half as wide again as the petiole. *enigmatus* Viereck
 Second segment of the gaster at least twice as wide as the petiole.....14
14. Lateral angles of the clypeus about the same distance from base and apex.....15
 Lateral angles of the clypeus about twice as far from the base as from the apex; surface of the clypeus coarsely punctate.....17
15. Surface of the clypeus finely punctate; petiole with lateral teeth visible when viewed dorsally; second segment of the gaster somewhat flattened dorsally, with dorsal and lateral angles distinct; markings yellowish-white.....*globulosus* Saussure
 Surface of the clypeus coarsely punctate; petiole with lateral teeth not visible when the insect is viewed dorsally; second segment of the gaster convex, with dorsal and lateral angles indistinct, about a third longer than wide; markings bright yellow.....*robustus* Isely
 Surface of the clypeus finely punctate; petiole with lateral teeth usually visible when viewed dorsally; second segment of the gaster convex with lateral and dorsal angles indistinct, segment short, little if any longer than wide; markings yellow.....16

16. Punctations of the first and second segments of the gaster dense; segments of the gaster largely black.....*coloradensis* Cresson
Punctations of the gaster sparse; gaster largely yellow..*xanthogaster* Isely
17. Petiole pyriform, widest at apical margin, more heavily punctate than the second segment of the gaster; markings yellowish-white; no dots on either side of the petiole.....*fraternus* Say
Petiole campanulate, widest before apical constriction, as heavily punctate as the second segment; markings of bright yellow; a dot on either side of the petiole.....*verticalis* Say
18. Sides of the prothorax before the tegulæ concave; second segment of the gaster with a broad depression before the apex extending to the sides, dorsal line strongly recurved apically, dorsal angle obtuse. *crassicornis* Isely
Sides of the prothorax contracted before the tegulæ, but convergent immediately before the anterior margin of the prothorax; depression on the second segment of the gaster not extending to the sides, dorsal line slightly recurved apically, dorsal angle near a right angle. *pachygaster* Isely

Smithii Group.

The smithii group contains brownish and yellowish species but none that are predominantly black. It differs from the others of the genus by the depth of the furrow of the propodeum, and on the ventral aspect of the petiole by the absence of carinæ along the margins of the tergite and the absence or reduction of punctations attaining these margins. *Smithii*, *belfragei* and *bollii* resemble each other in general appearance, and in particular by the shape of the clypeus and by the shape of the second segment of the gaster.

Eumenes brunneus new species.

Male.—Length, 12.5 mm.; wing, 9.5 mm. Clypeus long and narrow, lateral lines diverging but little apically, apical notch narrow, angular, surface slightly convex, not flattened apically, without brown chitinized median spot above the apex, very finely punctate; head flattened dorsally, densely punctate; thorax stout, nearly as broad as long, slightly rounded in front, strongly convex dorsally and laterally; sides of prothorax immediately before anterior margin, concave; propodeum separated with a deep median furrow; petiole elongate—three times as long as wide at the apex, pyriform, never abruptly inflated, punctations of medium depth, on ventral aspect of tergite sparse and not extending up to the margin; second segment of the gaster a third longer than wide, lateral lines divergent until nearly half-way from base then nearly parallel, transverse depression before median apical margin very slight, finely punctate, more densely apically than basally. General color ferruginous; ferrugino-testaceous on the antennæ and third to last segments of the gaster, ferruginous on the thorax and somewhat duller on the second segment of the gaster; wings subhyaline, yellowish-brown; clypeus, mandibles, anterior surface of the scape, emargination of the eyes, a post-ocular line, a wide band on the anterior

margin of the prothorax, a large patch below the tegulæ, tegulæ except a central spot, band on the anterior margin of the scutellum, metanotum, a spot on either side on the propodeum, lower half of the posterior margin of the propodeum, a wide band dorsally on the posterior margin of the petiole and narrower on the second segment of the gaster, indistinct bands on the following two segments, an indistinct cuneiform spot on either side of the second segment, ends of the femora, all of tibiæ and tarsi, yellow; median antennal segments, dorsal aspect of the head, anterior and posterior parts of the mesonotum, margins of the scutellum and the metanotum, ventral parts of the thorax, a stripe running up under the tegulæ, lower part of furrow of the propodeum, petiole except apical band, coxæ, trochanters and basal ends of femora, black. Covered with very fine golden pile.

Colorado. Described from one male.

Type: Cat. No. 21377, U. S. National Museum.

Of the North American members of this genus this species is the most distinct. In addition to the differences mentioned in the key it may be distinguished by the unusually long clypeus, the surface of which is convex, not being flattened apically, by the contrasting stoutness of the thorax and slenderness of the gaster, and the general brownish color. Because of the pyriform petiole and the absence of punctation along the ventral margin of the tergite it is placed in this group. A series of specimens including females might place it in a group by itself, but it certainly does not belong in any of the other species groups included in this paper.

Eumenes bollii Cresson.

Eumenes bollii Cresson, E. T., Trans. Amer. Ent. Soc. vol. 4, 1872, p. 232-233—Isely, Dwight, Kans. Univ. Sci. Bul. vol. 8, 1914, p. 252-253, 299-301.

Bollii is unique among the North American species by lacking punctations on the dorsal aspect of the petiole, and is further distinguished from the others of the *smithii group* by having a campanulate petiole.

Distribution.—This species inhabits southwestern United States and there is one specimen in the U. S. National Museum labeled "Mexico." Specimens from the United States are from the following localities: Brewster Co., Del Rio, Valverde Co., and Waco, McLennan Co., Tex.; Riley Co., Kans.; Rocky Ford, Otero Co., Colo.; Des Moines, Union Co., and Sacramento Mts., Otero Co., N. M.; Huachuca Mts., Ariz.; Reno, Washoe Co., Nev.; San Berdino Co. and Stratford, Kings Co., Calif. The writer has collected it in Ness, Trego, Osborne and Norton counties, Kansas.

Type.—Cat. No. 1725, U. S. National Museum.

The writer has collected nests of this species in western Kansas. They were one-celled globular earthen nests, characteristic of this genus and were found singly attached to weed stems.

Eumenes smithii Saussure.

Eumenes smithii Saussure, Henri de, Etud. Fam. Vespid., vol. 1, 1852, p. 43, pl. 10, fig. 1; Smithson, Miscl. Coll. No. 254, 1875, p. 104-105.

All records of this species and all specimens I have seen are from Florida.

Type.—British Museum of Natural History (according to Saussure).

Nothing has been recorded previously in regard to the nest of *smithii*. In the National Museum is a nest collected by Hubbard labeled Cres City, Fla., from which a wasp of this species was reared. It is a globular earthen nest, with a jug-like mouth, typical of the wasps of this genus. The surface is more granular than that of the nests of *fraternus* and small lumps of earth give it a roughened appearance. It is attached to the lower side of a leaf.

Eumenes belfragei Cresson.

Eumenes belfragei Cresson, E. T., Trans. Am. Ent. Soc., vol. 4, 1872, p. 232.—Hartman, Carl, Jour. Animal Behavior, vol. 3, 1913, p. 353-360.

Female.—Length, 16.5 mm.; wing, 11.5 mm. Clypeus as long as wide, lateral angles comparatively near the apex, apical emargination angular, surface deeply punctate; head slightly convex above; thorax slightly rounded in front, sides convex; median furrow in propodeum deep; petiole pyriform, never as wide as at the apex, margins of tergite usually meeting ventrally, completely obliterating the sternite except at the apex, no carinæ bordering the margins, punctations on ventral aspect not attaining the margin, except at the apex; second segment of the gaster convex, longer than wide, dorsal line before angle strongly curved forward; punctations on head and thorax confluent, less dense on gaster. Largely ferruginous; dorsal aspect of the head, tips of flagella, a spot near the upper middle of the clypeus, mesonotum, lateral aspect of the thorax, basal line on metanotum, median furrow of the prepodium, basal end of the petiole, basal and central aspect of tergite of the second segment of the gaster, black, eyes dull brownish; clypeus, ridge between the antennæ, anterior emargination of the eyes, a postocular line, anterior margin of the prothorax, a large spot below the tegulæ, anterior margin of the scutellum, metanotum, a large oblique spot on each side of the propodeum, apical margin of the petiole, elongate oblique spots on either side of the second segment of the gaster meeting

dorsally, apical margin of second, third and fourth segments, ends of femora, all of tibæ and tarsi, yellow; antennæ yellowish-ferruginous; scape yellowish beneath; wings hyaline, brownish. Covered with very fine golden pile.

Male.—Length, 13.75 mm.; wing, 9.5 mm. Clypeus narrower. Clypeus, hook of the antennæ and apical margin of all segments of the gaster, yellow; oblique spots on sides of the propodeum absent.

Variations.—Margins of the tergite of the petiole do not always meet ventrally and in a few specimens the ventral punctations attain the margins of the tergite before the apical divergence. The apex of the tergite of the second segment of the gaster is often much flattened. There is considerable variation in the amount of black and the yellow oblique marks on the second segment of the gaster frequently do not meet on the dorsum.

Distribution.—Specimens in the National Museum are from Riley and Franklin Counties, Kansas; La Cuena, Mora Co., N. M.; Huntersville, Walker Co., Victoria, Victoria Co., Corpus Christi, Nueces Co., Del Rio, Valverde Co., Brewster Co., Pittsburg, Camp Co., Ladonia, Fannin Co., Greenville, Hunt Co., Calvert, Robinson Co., Dallas, Dallas Co., and Cypress Mills, Blanco Co., Texas. These localities in Texas indicate a very general distribution over the state.

Type.—Cat. No. 1726, U. S. National Museum.

This species is closely related to *smithii*, so closely that the writer has not been able with all specimens, to separate the two species except by color. The punctation character used in the key is satisfactory with most specimens, but because of a few exceptions is not entirely dependable.

Hartman has given a detailed description of the building of two nests by wasps of this species, which as far as the writer is aware is the only account of actual nest building of any American Eumenes. A few points in his account may be summarized as follows: The nests were typical jug-shaped earthen cells, attached singly to culms of Bermuda grass. Earth for building material was secured from a hard clod, or a hardened place in a path, and was moistened by water carried in the crop. The work of building was done with the mandibles and forefeet. After the base was made, a pellet of earth was spread out as a ribbon around the edge of the nest and then pulled thin to the normal thickness. Oviposition occurred before storing the nest. Geometrid caterpillars were used as food for the wasp grubs.

Eumenes belfragei sub species, **aureus** new subspecies.

Female.—Like the typical *belfragei* in structure, but differing strikingly in color, due to the replacing of black and ferruginous largely by yellowish-ferruginous and yellow. Black confined to the dorsal aspect of the head, middle of the mesonotum, base of the petiole, anterior margin of the mesosternum, posterior margin of the epimeron and base of the petiole; ferruginous on the mesonotum, petiole and second segment of the gaster, grading to yellowish-ferruginous on the sides and ventral aspect of the thorax; a narrow oblique band on either side of the second segment of the gaster, ferruginous; yellow markings the same as in the typical *belfragei*, except that the entire clypeus, the greater part of the second segment of the gaster and the following segments are yellow.

Brewster Co., Texas. Described from one female.

Type.—Cat. No. 21378, U. S. National Museum

Crucifera Group.

This group would fall in Saussure's division Pachymenes, and includes those species with the gaster depressed, the petiole very broad and campanulate, and the wings large. The group can not be distinctly separated from the *fraternus group; bolliformis* is distinct from the species of any other group, but *stenogaster* resembles *globulosus*, while *sternalis* might be confused with *coloradensis*.

Eumenes crucifera Provancher.

Eumenes crucifera Provancher, Abbe L., Faune Hymen. de la Prov. Quebec, 1886, p. 421.

Distribution.—Specimens in the National Museum are from Los Angeles Co., Humbolt Co., Folsom, Sacramento Co., and Palo Alto, Santa Clara Co., California.

Type.—Cat. No. 1978, U. S. National Museum.

Eumenes bolliformis Viereck.

Eumenes bolliformis Viereck, H. L., Trans. Am. Ent. Soc., vol. 33, 1907, p. 387-388. Fig.

Distribution.—Flagstaff, Coconino Co., Ariz., (Viereck), and Huachuca Mts., Ariz.

Type.—Snow Collections, University of Kansas, Lawrence, Kansas.

This species superficially resembles *crucifera*, but is much larger, the gaster is proportionately wider and the second segment more depressed.

Eumenes stenogaster new species.

Female.—Length, 13 mm.; wing, 10 mm. Clypeus longer than wide, lateral angles nearer base than in *fraternus*, apical emargination moderately deep, angular, basal emargination narrow, rounded, surface coarsely punctate; thorax truncate in front, convex laterally, median furrow of propodeum deep; petiole campanulate, nearly half as wide at apex as long, punctations deep and of medium density; second segment of the gaster depressed, as wide as long, dorsal angle rounded, lateral angles attained far before the middle, beyond these angles the lateral lines are nearly parallel, punctations as on petiole. Black; clypeus, except a pediculate spot suspended from the basal margin, a line on the anterior aspect of the scape, the ridge between the antennæ, anterior margin of the prothorax, a dot on either side of the anterior margin of the mesonotum in front of the tegulæ, a spot below the tegulæ, an obscure dot on either side of the scutellum, metanotum, large oblique spots on either side of the propodeum, a large spot on either side of the petiole, a broad oblique band on either side of the second segment of the gaster nearly meeting on the dorsum, apical margins of all the segments of the gaster except the last, particularly wide on the second segment broadening into a helmet shaped spot ventrally, ends of anterior and median femora, the same pairs of tibiæ, yellow; all tarsi, ends of posterior femora and posterior tibiæ, testaceous; wings subhyaline, brownish; body covered with dense grayish pile, finer on the second segment of the gaster.

Male.—Length, 13 mm.; wing, 10 mm. Clypeus broad for a male, distinctly toothed, gaster less densely and coarsely punctate than that of the female. Clypeus all yellow, tegulæ margined with yellow; hook of antennæ, brown. Otherwise as the feamle.

Described from one female collected by C. H. T. Townsend, Rio Ruidoso, White Mts., N. M., and one male from Beaver Canyon, Utah.

Type.—Cat. No. 21379, U. S. National Museum.

Eumenes sternalis new species.

Female.—Length, 12 mm.; wing, 10 mm. Clypeus longer than wide, lateral angle little more than midway from base to apex, slightly convex, flattened apically, apical emargination rounded, basal emargination narrow and shallow, surface finely punctate; thorax convex laterally, median furrow of propodeum shallow; petiole abruptly campanulate, medium width, as wide or wider before apical contraction than after it; second segment of the gaster depressed, a little longer than wide, wide transverse depression before the apex extending to the sides, lateral angles distinct, nearer base than apex, lateral lines beyond angles converging apically; punctations on gaster shallow and of medium density. Black; clypeus except a central spot, a line on the anterior aspect of the scape, the ridge between the antennæ, a very fine postocular line, anterior margin of the prothorax, a spot below the tegulæ,

a dot on either side of the scutellum, metanotum, a spot on either side of the propodeum, an obscure dot on either side of the petiole, wide oblique bands on either side of the second segment of the gaster, apical margins of all segments of the gaster, yellow; tips of mandibles, tegulæ, and legs, testaceous. Covered with golden pile, long on head and thorax, grading to medium length on the second segment of the gaster.

Male.—Length, 11.5 mm.; wing, 10 mm. Clypeus with lateral angle near to a right angle, apical emargination angular, basal emargination deep, much like that of a *fraternus* male. Clypeus yellow.

Described from one female from Beaver Canyon, Utah, and one male from New Mexico.

Type.—Cat. No. 21380, U. S. National Museum.

Fraternus Group.

The *fraternus group* is the most homogeneous of all the groups under consideration. While it contains some large species the majority are smaller than those of the two groups previously discussed. With the exception of *cruciferorum* and *tricinctus* which are the odd members of the group, the apical emargination of the clypeus is rounded, the second segment of the gaster is without a boss on the dorsal angle and the resulting apically recurved dorsal line, which characterizes the following group and to a large extent the preceding one. All species have the second segment of the gaster convex and little depressed.

Eumenes fraternus Say.

Eumenes fraternus Say, Thomas, Narr. Long's Second Expedition, vol. 2, 1824, p. 344-346.—Harris.*, T. W., Boston Cultivator, vol. 10, 1848, p. 225.—Saussure, Henri de, Etud. fam. Vespid., vol. 1, 1852, p. 40.—Say, Thomas, Writings of Th. Say, (LeConte, J. L.), vol. 1, 1859, p. 232.—Walsh, B. D. and Riley, C. V., Amer. Ent., vol. 1, 1869, p. 138.—Riley, C. V., Second Ann. Rept. Ins. Mo., 1870, p. 103.—Couper, W., Canad. Ent., vol. 3, 1871, p. 62.—Saussure, Henri de, Smithson. Miscl. Coll., No. 254, 1875, p. 95-98.—Riley, C. V., Amer. Ent., vol. 3, 1880, p. 180.—Saunders, S., Rept. Fruit Growers Assoc. Ont., 1882, p. 281.—Provancher, L., Natural. Canad., vol. 13, 1882, p. 144, 678.—Riley, C. V., Third Rept., U. S. Ent. Comm., 1883, p. 117.—Southwick, E. B., Insect Life, vol. 5, 1892, p. 107-108.—Britton, W. E., Eighth Rept. Conn. State Ent., 1909, p. 786.—Smith, J. B., Ann. Rept. N. J. State Mus. for 1909, 1910, p. 669.—Isely, Dwight, Kans. Univ. Sci. Bul., vol. 8, 1914, p. 253-254, 301.—Viereck, H. L., Conn. State Geol. and Nat. Hist. Surv. Bul. 22, 1916, p. 635.

Eumenes fervens Saussure, Henri de, Etud. fam. Vespid. vol. 1, 1852, p. 40.

Eumenes macrops Saussure, Henri de, Etud. fam. Vespid. vol. 1, 1852, p. 41.

Eumenes minuta Saussure, Henri de, Etud. fam. Vespid. vol. 1, 1852, p. 39.

*Reference not verified by the writer.

Female.—Length, 15 mm.; wing, 11.5 mm. Clypeus convex, lateral angles two-thirds distance from base to apex, apical emargination rounded, surface coarsely punctate; head convex above; thorax convex before tegulæ; propodeum with median furrow deep, extending to the metanotum; petiole little more than one-third as wide as long, at first linear then gradually becoming pyriform, widest at apical margin, lateral teeth not visible dorsally, apical margin bordered by a salient cordon before which is a slight constriction; second segment of the gaster convex, not depressed, more finely punctate than the petiole. Black; wide basal margin of the clypeus extending forward along the sides, ridge between the antennæ, anterior aspect of the scape, a post-ocular line, anterior margin of the prothorax, metanotum, a spot on either side of the metanotum on the propodeum, apical margins both dorsal and ventral of the first and second segments of the gaster, dorsal margin of third and fourth segments, an oblique spot on either side of the second segment, a line on the lateral aspect of the tibiæ most prominent on the median pair, yellowish-white; ends of tibiæ and tarsi, piceus; outer margins of tegulæ brownish; wings brownish with violet reflections. Body covered with short, grayish pile.

Male.—Length, 12.5 mm.; wing, 10 mm. More slender than female. Clypeus widely divergent apically. Clypeus entirely and nearly all of tibiæ, yellowish-white; hook of antennæ brown; no spots on the propodeum. Otherwise as female.

Variations.—This species varies considerably in size, in the depth of the furrow of the propodeum, in the prominence of the lateral teeth of the petiole, which may be observed on a few specimens when viewed dorsally, and in the density and depth of punctation. The markings vary in prominence, particularly in males which frequently have a line on the margin of the fifth segment of the gaster, and more of the legs yellowish-white. There are two varieties with somewhat different markings, which are as follows:

Variety 1. Resembles the typical *fraternus*, except as follows: Length, 16.5 mm.; wing, 12.5 mm. Melanistic. No yellowish white on clypeus nor on legs except for a small mark on median tibæ, nor on third and fourth segments of the gaster. There is a large yellowish-white spot below the tegulæ.

Variety 2. Resembles the typical *fraternus*, except as follows: A spot below the tegulæ, spots on the propodeum very large, a dot on either side of the petiole, and apical margins of all segments of the gaster 1 to 5, yellowish white. Because of these variations in markings this variety might be confused with *verticalis*, but it differs in all structural characters. In the National Museum are only three specimens so marked.

Distribution.—The writer has seen specimens of the typical *fraternus*, most of which are in the National Museum, from the following localities: Durham, Stafford Co., N. H.; Forest Hills and Boston, Mass.; Lake George, Warren Co., and Long Island, N. Y.; Carlisle Junction, Craighead and Eberly Mills,

Cumberland Co., Campbell, York Co., Heckton Mills, High Spire and Rockville, Dauphin Co., North East, Erie Co., Martie Forge, Lancaster Co., and Philadelphia, Pa.; Cabin John and Plummers Island, Montgomery Co., and Linwood, Carroll Co., Md.; Washington, D. C.; Chain Bridge, Alexandria Co., Dixie Landing, Pohick Run, Newington, and Mt. Vernon, Fairfax Co., Va.; Highlands, Macon Co., N. C.; Jacksonville, Duval Co., Fla.; Holly Springs, Marshall Co., Miss; Lake Charles, Calcasieu Co., La.; Mich.; Corydon, Harrison Co., Borden, Clark Co., and Noblesville, Hamilton Co., Ind.; Riley Co. and Lawrence, Douglas Co., Kans.; West Cliff, Custer Co., Colo.; Dallas, Dallas Co., Denton, Denton Co., Paris, Lamar Co., Victoria, Victoria Co., and Wolf City, Hunt Co., Texas; in the United States and one specimen labeled Canada.

Specimens of the melanistic variety, (No. 1) are from New Orleans, La.; Jacksonville, Duval Co., Fla.; and Victoria, Victoria Co., Texas.

All specimens of variety No. 2 are labeled New Jersey.

To the states listed above, Connecticut may be added, as the species is recorded from that state by both Viereck and Britton.

Neotype.—Determined by the writer. U. S. National Museum.

This species is larger and more slender than any other belonging to this group and the petiole is pyriform while with the others it is more or less distinctly campanulate. In these respects it resembles the species of the *smithii group*.

Fraternus is the commonest of the American species and its habits are the best known. Accompanying Say's original description of the species is also a description of the globular nest with the opening terminated by a jug-like mouth. The nest has subsequently been described by a number of observers, and is known to occur singly or in groups of 2 to 5, on the surface of stones or leaves or attached to twigs or weed stems. Lepidopterous larvæ are stored as food for the wasp grubs. According to Say they store nocturnal Lepidoptera; Harris records the storing of canker-worms (*Anisopteryx vernata* Peck.); Norton in a note in Saussure's Synopsis records the storing of green diurnal Lepidoptera; Southwick describes the destruction of the parsnip web-worm (Depressaria heraclina De G.)

Eumenes verticalis Say.

Eumenes verticalis Say, Thomas, Narr. Long's Second Expedition, vol. 2, 1824, p. 346.—Saussure, Henri de, Etud fam. Vespid. vol. 1, 1852, p. 41.—Say, Thomas, Writings of Th. Say (LeConte, J. L.), vol. 1, 1859, p. 233-234.

Female.—Length, 11.75 mm.; wing, 9.25 mm. Similar to *fraternus*, from which it differs as follows: Thorax stouter, furrow of the propodeum shallow, scarcely reaching the metanotum; petiole and second segment of the gaster wider in proportion to length than those of *fraternus*, petiole distinctly campanulate, widest before apical constriction, apical constriction and apical cordon more pronounced than with *fraternus;* second segment of the gaster about as coarsely punctate as the first. Black, but less shining than *fraternus;* basal half of clypeus extending forward along the sides, greater part of the tegulæ, a spot below the tegulæ, an oblique mark on the propodeum on either side of its jointure with the petiole instead of higher on either side of the metanotum as in *fraternus*, apical margins dorsal and ventral of all segments of the gaster from one to five, a dot on either side of the petiole, an elongate oblique mark on either side of the second segment of the gaster instead of a spot, ends of femora and greater part of tibia, and all other markings found on *fraternus*, bright yellow instead of yellowish white; tarsi testaceous; center of tegulæ rufous; wings brownish. Covered with pile of medium length.

Male.—Length, 10 mm.; wing, 7.5 mm. Clypeus entirely yellow; no spot below the tegulæ nor on the propodeum. Otherwise like the female.

Variations.—The amount of yellow on the clypeus is variable. The spot below the tegulæ is absent on about half the specimens at hand, one lacks the marks on the propodeum and another lacks the dots on the petiole. The yellow on the segments of the gaster varies with individuals.

Distribution.—The species was described by Say from Pennsylvania. The National Museum contains specimens from the following localities: Forest Hills, Suffolk Co., Mass.; Philadelphia, Pa.; Chain Bridge and East Falls Church, Alexandria Co., Va.; Ind.; Mo.; Volga, Brookings Co., S. D.; and West Cliff, Custer Co., Colo.

Neotype.—Determined by the writer. U. S. National Museum.

This species is often confused with *fraternus* in collections, with which Dalla Torre (Catalog. Hymen; vol. 9, 1894, p. 33), suggests that it is a possible synonym. The two species are readily separated by their difference in size, by the structure of the first and second segments of the gaster, by the color and color pattern.

Eumenes globulosus Saussure.

Eumenes globulosus Saussure, Henri de, Etud. fam. Vespid. Supplement, 1859, p. 139; Smithson. Miscl. Coll., No. 254, 1875, p. 101-102.—Smith, J. B., Ann. Rept. N. J. State Mus., for 1909, 1910, p. 669.

Female.—Length, 13.5 mm.; wing, 10 mm. Like *fraternus* from which it differs as follows: Clypeus with lateral angles slightly nearer apex than base, apical emargination more shallow, surface finely punctate; furrow in the propodeum inconspicuous, not extending upward to the metanotum; petiole campanulate, nearly half as wide as long, lateral teeth visible dorsally, no conspicuous contraction before the apical cordon; second segment of the gaster nearly as wide as long with the dorsal angle abrupt, more flattened dorsally and more finely punctate than *fraternus*. Black; larger part of clypeus, a spot on the tegulæ, a spot below the tegulæ, the spot on either side of the second segment of the gaster elongated into an oblique line, apical margins of all segments of the gaster 1 to 5, yellowish-white; ends of tibæ, tarsi and wings brown. Covered with grayish pile of medium length and density.

Male.—Length, 10 mm.; wing, 8.25 mm. Differs from the female as follows: More slender, clypeus narrower, with lateral angles less prominent than those of *fraternus*. Clypeus entirely, and the margin of the sixth segment of the gaster and more surface of the legs, yellowish-white. Spots below the tegulæ and on the sides of the propodeum absent.

Distribution.—The range of this species overlaps that of *fraternus* and extends north of it. Saussure records it from Illinois and Wisconsin in the United States and from Great Slave Lake in Canada. In the National Museum are specimens labeled as follows: Waldoboro, Lincoln Co., Me.; Durham, Strafford Co., N. H.; Mass.; N. J.; Ind. and Mich; in the United States, and Montreal, Province of Quebec, and a number of other specimens simply labeled Canada.

Type.—Probably in the Museum of Geneva, Switzerland.

Like *verticalis*, this species is frequently confused with *fraternus*. In many respects it is much like both of the above species and also like *coloradensis*. The clypeus in general shape and in its fine punctation resembles *coloradensis* rather than *fraternus* or *verticalis*. The campanulate petiole resembles that of *verticalis* and *coloradensis*, while the prominence of the teeth of the petiole resembles that of *coloradensis* and is unlike that of the others. It resembles *fraternus* and differs from the other two by having the second segment of the gaster less distinctly punctate than the petiole, by the shining black color and markings of yellowish-white, instead of bright yellow.

The color pattern, however, is more like that of *verticalis* and on none of the four species are the markings as extensive as on *coloradensis*. *Globulosus* is unique among the four species by the failure of the furrow of the propodeum to extend upward to the metanotum and by the broader and more depressed second segment of the gaster.

Eumenes coloradensis Cresson.

Eumenes coloradensis Cresson, E. T., Rept. Geog. and Geol. Surv. West of the 100th Meridian, vol. 5, 1875, p. 717-718.

Distribution.—Described from Colorado. In the National Museum are specimens from West Cliff, Custer Co., Colo.; Beulah, San Miguel Co., Hell's Canyon and White Mts., N. M.; and Beaver Canyon, Fremont Co., Idaho.

Type.—In Museum of the Philadelphia Academy of Natural Sciences. (According to Cresson).

Eumenes xanthogaster new species.

Male.—Length, 10.75 mm.; wing, 8.25 mm. Clypeus narrow, lateral angles obtuse, almost as near to base as to apex, apical emargination rounded, basal emargination deeper than that of *fraternus*, surface finely punctate; thorax truncate in front, convex laterally; furrow of propodeum of moderate depth; petiole campanulate, widest before apical constriction, inflation more abrupt than that of *fraternus*, lateral teeth not visible from above, punctations deep and sparse, second segment of the gaster as wide as long, dorsal and lateral lines convex, punctations finer than on first segment becoming more dense apically. Black; clypeus, anterior aspect of the scape, ridge between the antennæ, a very short post-ocular line, anterior margin of the prothorax, outer margin of the tegulæ, a spot below the tegulæ, a spot on either side of the scutellum, metanotum, a spot on either side of the petiole, a narrow band on the apex, on the second segment of the gaster large elongate lateral spots nearly meeting dorsally and confluent with the wide apical band, ventrally the apical two-thirds of the second segment of the gaster, and the succeeding segments, both dorsally and ventrally, except basal black bands, yellow; ends of femora, all of tibiæ and tarsi, testaceous; wings brownish. Pile very fine on clypeus, long on the dorsal aspect of the head and thorax, and grading to fine on the second segment of the gaster.

Los Angeles Co., Calif. Described from three males collected by the late D. W. Coquillet.

Type.—Cat. No. 21381, U. S. National Museum.

This species is closely allied to *coloradensis* but in addition to the characters mentioned in the key it may be distinguished

by the smaller lateral teeth on the petiole which can not be seen when the insect is viewed dorsally, and by the slightly shorter second segment of the gaster.

Eumenes robustus new species.

Female.—Length, 13.5 mm.; wing, 11.25 mm. Clypeus longer than wide, lateral angle midway between base and apex, apical emargination rounded and very shallow, surface densely and coarsely punctate; thorax convex; propodeum with median furrow shallow; petiole campanulate but not distinctly so, linear for nearly half its length then becoming comparatively wide, widest at apex, lateral teeth not visible dorsally; second segment convex when viewed either dorsally or laterally, angles not distinct; punctations of the petiole of medium coarseness and density, finer and sparser on the second segment. Black; clypeus except a central spot, a line on the anterior aspect of the scape, a ridge between the antennæ, anterior margin of the prothorax, tegulæ except a central spot, a spot below the tegulæ, a spot on either side of the scutellum, metanotum, a spot on the propodeum on either side of the metanotum, a spot on either side of the petiole, a large oblique cuneiform spot on either side of the second segment of the gaster, apical cordon of the petiole, wide apical margin of the second segment both ventral and dorsal, and the succeeding segments except the basal margins of the sternites, legs beyond the bases of the femora, yellow; a spot in the center of the tegulæ, rufous; wings hyaline with golden reflections. Body covered with fine golden pile.

Male.—Length, 13.5 mm.; wing, 11 mm. Clypeus narrow, with lateral angle much nearer apex than base, yellow; hook of antennæ, brown; no yellow on propodeum. Otherwise as female.

Described from one female from Beulah, San Miguel Co., N. M.; and from one male from Williams, Coconino Co., Ariz. The National Museum also has specimens from Ft. Collins, Larimer Co., Colo. and from Oregon.

Type.—Cat. No. 21382, U. S. National Museum.

Although not as long as *fraternus* this species is the most robust in the group. This character and the distinct markings readily distinguish this species from any of the others.

Eumenes enigmatus Viereck.

Eumenes enigmatus Viereck, H. L., Trans. Am. Ent. Soc., vol. 33, 1908, p. 389, pl. 12.

Distribution.—Flagstaff, Coconino Co., Ariz. (Viereck); Ornsby Co., Nev.; Boulder Co., and Florissant, Teller Co., Colo.

Type.—Snow Collections, University of Kansas, Lawrence, Kansas.

Eumenes cruciferorum Viereck.

Eumenes cruciferorum Viereck, H. L., Trans. Am. Ent. Soc.; vol. 33, 1908, p. 388-389, pl. 13.

Distribution.—Flagstaff, Coconino Co., Ariz. (Viereck); Pecos, San Miguel Co., N. M.

Type.—Snow Collections, University of Kansas, Lawrence, Kansas.

Eumenes tricinctus new species.

Female.—Length, 11 mm.; wing, 8.5 mm. Clypeus slightly longer than wide, apical emargination of moderate depth, obtusely angular, basal margin slightly incurved, punctations shallow and dense; thorax truncate in front, sides between anterior margin and tegulæ little convex; furrow of propodeum shallow; petiole campanulate, two-fifths as wide as long, inflation gradual beginning about halfway from base; second segment of the gaster longer than wide, dorsal and lateral lines convex, dorsal angle surmounted by a boss or hump making it higher than the apical part of the segment, dorsal line recurved apically, depression before apical margin wide extending to the sides; punctation on the gaster medium. Black; clypeus except a black spot in the center, a ridge between the antennæ, a line on the anterior aspect of the scape, a post-ocular line, a band on the anterior margin of the prothorax, oblique bands on the anterior margin of the mesonotum, tegulæ, spots below the tegulæ, anterior half of the scutellum, metanotum, convexities of the propodeum, a large spot on either side of the petiole confluent with the band on the apical margin, three wide bands on the tergite of the second segment of the gaster, two of which are interrupted medially, the apical one entire, the ventral part of the segment and all of the succeeding segments except basal black bands, ends of femora and all of tibiæ, yellow; tarsi, testaceous; wings, hyaline, brownish; pile long on the head and thorax grading to fine on the second segment of the gaster.

Oregon. Described from two females. The National Museum also has one specimen from Los Angeles Co., California.

Type.—Cat. No. 21383, U. S. National Museum.

This is a slender wasp, closely related to *cruciferorum*.

Crassicornis Group.

These two species are readily distinguished from the others discussed in this paper by their general stoutness, the thick, short antennæ, the stoutness of the thorax and the gaster, and the abruptness of the dorsal angle and the recurved dorsal line of the second segment of the gaster. They are related to *iturbide* Saussure.

Eumenes crassicornis new species.

Male.—Length, 11.5 mm.; wing, 9 mm. Clypeus very wide for a male, as wide as long, apical emargination angular, basal margin slightly incurved, punctation medium; antennæ comparatively short and stout, reaching back to tegulæ; thorax stout, truncate in front, sides of prothorax from anterior margin to tegulæ concave; furrow of the propodeum wide and deep; petiole only twice as long as wide, much the widest at the apex with no distinct contraction before it, comparatively flat, punctations medium; second segment of the gaster as wide as long, convex dorsally, dorsal angle abrupt, dorsal line strongly recurved apically, transverse depression before the apex extending to the sides, punctations fine and of medium density. Black; a wide median, longitudinal band covering two-thirds of the surface of the clypeus, a dot between the antennæ, a fine post-ocular line, anterior margin of the prothorax, posterior margin of the tegulæ, a line on the posterior of the metanotum, a very small dot on either side of the first and second segments of the gaster, dorsal apical margin of the segments of the gaster one to four, and the ventral margin of the second segment, a longitudinal band on the anterior tibiæ, ends of femora and all of tibiæ of middle and posterior legs, yellow; hook of antennæ, tegulæ, tarsi and wings, brown. Grayish pile, tinged with golden, long and dense on the head and thorax, shorter on the petiole and fine on the second segment of the gaster.

Goldstream, British Columbia, Dominion of Canada. Described from one male specimen. The National Museum has also one specimen from Seattle, Wash.

Type.—Cat. No. 21384, U. S. National Museum.

This species is the most nearly black of any known to the writer within the geographical limits prescribed by this paper. It is the only male with black on the clypeus, and the only species besides pachygaster lacking the yellow ridge between the antennæ and the line on the scape, while the dots on the sides of the second segment of the gaster are so obscure that they might readily be missed altogether.

Eumenes pachygaster new species.

Female.—Length, 11.5 mm.; wing, 9 mm. Clypeus as long as wide, apical margin nearly truncate, with slightly rounded emargination, punctations of medium depth and sparse; antennæ comparatively short and stout, reaching back about to the tegulæ; thorax truncate in front, sides convex, but contracted immediately before the tegulæ; furrow of the propodeum not deep; petiole short, less than twice as long as wide at the apex, campanulate with distinct contraction before the apex, punctation of medium depth and distribution extending to the ventral margins of the tergite; second segment of the gaster almost cubical,

wider than and as high as long, dorsal angle near to a right angle, dorsal line recurved apically, transverse depression before the apex broad, but not extending to the sides, punctations fine and of medium density. Black; basal third of clypeus, a spot between the antennæ, a post-ocular line, anterior margin of the prothorax, the greater part of the tegulæ, metanotum, a spot on either side of and below the metanotum on the propodeum, a dot on either side and the margin of the petiole, a wide oblique line on either side of the second segment of the gaster, posterior margins of the second to fifth segments, a dot on either side of the apical margin of the sternite of the second segment, tips of the femora and a band on the tibæ, yellow; a spot on the tegulæ, and tarsi, brown; wings, hyaline, brownish. Pile grayish, fine and sparse on clypeus, dense on the scape, long and dense on the head, medium on thorax and gaster.

Mountain View, Santa Clara Co., Calif. Described from three females collected by W. H. Ashmead. These specimens were marked as a new species by Dr. Ashmead. In the National Museum is another specimen from Menlo Park, San Mateo Co., Calif.

Type.—Cat. No. 21385, U. S. National Museum.

Species not Included in the Above

There are two described species which are found within the geographical limits prescribed for this paper, which the writer has not seen, for which reason they are not included in the tables and discussion of species. They are as follows:

Eumenes marginilineatus Viereck.

Eumenes marginilineatus Viereck, H. L., Trans. Em. Ent. Soc., vol. 33, 1908, p. 381.

Distribution.—Estes Park, Larimer Co., Colo. (Type locality).

Type.—Snow Collections, University of Kansas, Lawrence, Kansas.

Eumenes globulosiformis Viereck.

Eumenes globulosiformis Viereck, H. L., Trans. Am. Ent. Soc., vol. 33, 1908, p. 386-387.

Distribution.—Thomas' Ranch, Oak Creek Canyon, near Flagstaff, Coconino Co., Ariz. (Type locality).

Type.—Snow Collections, University of Kansas.

Genus *Zethus* Fabricius.

The five representatives of this genus found in America north of Mexico are readily divided into two groups which may be called after the oldest species in each, the *spinipes group* and the *poeyi group*. The first would fall into the Division *Zethusculus* Saussure and the second into the Division *Didymogastra* Perty. Saussure regarded the separation of the latter division from the former, which was based on the different lengths of the subpetiole, as "entirely empirical and should not be preserved except to facilitate the determination of species." However with the limited number of species covered by this paper the two groups are quite distinct.

Key to the Species of Zethus.

1. Robust species; clypeus triangular; depth of head behind the eyes greater than before their hind margin; concavity of the propodeum wide; small spines on the lateral aspect of the middle and posterior tibiæ; petiole constricted apically, gaster black or blackish (*spinipes group*).....2
 Slender species; clypeus oval; depth of head behind the eyes less than before their hind margin; concavity of the propodeum not pronounced; no spines on the lateral aspect of the tibiæ; petiole much narrowed, but not constricted apically; gaster after the subpetiole reddish (*poeyi group*)..4
2. Petiole half as wide as long, greatest width nearer the apex than the base; area on the mesonotum adjacent to the tegulæ not distinctly defined, sparsely punctate.....3
 Petiole much more inflated, two-thirds as wide as long, greatest width nearer the base than the apex; area on the notum adjacent to tegulæ distinctly defined and impunctate.....*substricta* Haldeman
3. Pronotal lobe impunctate basally; little yellowish on dorsal aspect of the thorax.....*spinipes* Say
 Pronotal lobe densely punctate basally; much yellowish on the dorsal aspect of the thorax.....*variegatus* Saussure
4. Clypeus without teeth apically.....*poeyi* Saussure
 Clypeus with three teeth apically.....*slossonæ* Fox

Zethus spinipes Say.

Zethus spinipes Say, Thomas, Bost. Jour. Nat. Hist., vol. 1, 1837, p. 387-388.—Saussure, Henri de, Etud. fam. Vespid., vol. 3, 1854, p. 122.—Say, Thomas, Writings of Thomas Say, (LeConte, J. L.), vol. 2, 1859, p. 767.—Saussure, Henri de, Smithson, Miscel. Coll. No. 254, 1875, p. 29.

Eumenes pennsylvanica Haldeman, S. S., Proc., Phila. Acad. Sci., vol. 6, p. 365.

Female.—Length, 14.75 mm.; wing, 12.5 mm. Mandibles 4-toothed, first tooth distinctly longer than the second; clypeus roughly triangular, nearly twice as wide as long, basal margin narrow, concave, sides slightly convex, somewhat indented by the insertion of antennæ, and widely divergent apically, apical lateral margin not distinctly separated from the genæ, apical margin truncate, with two small teeth, surface strigose in median portion, coarsely punctate elsewhere; small carinæ on inner margins of insertion of antennæ, area between the antennæ strigose; head greatly inflated behind the eyes, deeper behind the eyes than before their hind margin; pronotal lobe impunctate; mesonotum

with a median carina extending backward from the anterior margin, and two impressed lines extending forward from the posterior margin dividing it into three equal parts; adjacent to the tegulæ is a sparsely punctate area indistinctly defined by an impressed line; scutellum divided by a median impression; petiole twice as long as wide, at first linear then inflated, greatest width distinctly nearer apex than base, apical cordon distinct with three depressions immediately before it, deeply but not densely punctate; second segment of the gaster subpetiolate, nearly as wide as long, tergite finely and sparsely punctate, sternite finely and comparatively densely punctate; lateral aspect of median and hind tibiæ with irregular rows of spines. Black; a spot on the clypeus on either side of the basal margin, carinæ on inside margin of the insertion of the antennæ, an indistinct mark on either side of the anterior margin of the prothorax, apical margin of the tegulæ, a dot on either side of the metanotum, apical cordon of the petiole, margin of the second segment of the gaster, yellow; legs becoming brownish toward tarsi; wings brownish with violet reflections.

Distribution.—Originally described from Indiana. Saussure records its distribution as follows: Conn., Pa., Ill., Tenn., Ind. and Fla. The neotype is from Harrison Co., Ind., collected by Harold Morrison. The National Museum also contains other specimens from Washington, D. C.

Neotype.—Determined by the writer. U. S. National Museum.

Zethus variegatus Saussure.

Zethus variegatus Saussure, Henri de, Etud. fam. Vespid., vol. 1, 1852, p. 13-14; Rev. and Mag. Zool., vol. 10, 1858, p. 66.

Zethus bicolor Saussure, Etud. fam. Vespid, vol. 1, 1852, p. 17.

Zethus spinipes, var. *variegatus* Saussure, Smithson. Miscel. Coll., No. 254, 1875, p. 30.

Female.—Length, 14.5 mm.; wing, 12.5 mm. Differs from *spinipes* as follows: Pronotal lobes densely punctate basally. Dorsal aspect of the prothorax, a large spot under the tegulæ, scutellum except margins and the median line, metanotum, large spots on the convexities of the propodeum, wide apical margin of the tergite of the petiole, apical margins of the tergites of the second and third segments of the gaster, and the ventral margin of the second segment, yellowish; legs brownish.

Male.—Length, 13.75 mm.; wing, 10.25 mm. Differs from the female as follows: More slender. Clypeus punctate, not rugose, yellow except lateral and basal margins; antennæ hooked.

Distribution.—Originally described from Pennsylvania. Specimens in the National Museum are from the following localities: Md; Va; S. C; Tifton, Tift Co., Ga; and Victoria, Victoria Co., Dallas, Dallas Co., Texas; and Washington, D. C.

Type.—According to Saussure in the collection of M. de Romand.

The color differences between this species and *spinipes* are striking, and as far as the writer has observed, there is no tendency for the markings to intergrade. This wasp was first described by Saussure, although he later regarded it as a color variety of *spinipes*. While the writer might hesitate to establish a new species based on characters of punctation and color with a small series, yet since the species has been named it would seem preferable to preserve the name until the characters upon which it is based are shown to be unstable.

Zethus substrictus Haldeman.

Zethus substrictus Haldeman, S. S., Proc. Phila. Acad. Nat. Sci., vol. 2, 1844, p. 54.—Saussure, Henri de, Etud. fam. Vespid., vol. 3, 1854, p. 152.

Zethus spinipes var. *substrictus*, Saussure, Henri de, Smithson. Miscel. Coll., No. 254, 1875, p. 30.

Female.—Length, 16.5 mm.; wing, 13.75 mm. Differs from *spinipes* as follows: Mesonotum with median carina more distinct, area just within tegulæ distinctly defined by a depressed line, impunctate; petiole two-thirds as wide as long, sublinear at basal end and then rapidly inflated, greatest width nearer base than apex, apical cordon distinct with only one depression before it, punctations less distinct; second segment of the gaster longer after the subpetiole. Black; no spots on the clypeus and metanotum; a line on either side of the anterior margin of the prothorax instead of an indistinct mark, a spot on either side below the tegulæ, a spot on either side of the furrow of the propodeum, yellow; antennæ beyond the scape and all of legs, brownish.

Male.—Length, 13.75 mm.; wing, 10.5 mm. Differs from the female as follows: Basal line of the clypeus wider and more nearly truncate, surface punctate and not strigose, petiole more slender. Black; apical half of clypeus, anterior aspect of the scape of the antennæ, apical margin of the third segment of the gaster, yellow; antennæ, gaster and tegulæ, brownish; no spot on the anterior margin of the prothorax, below tegulæ, nor on propodeum.

Distribution.—Pennsylvania and Long Island, New York.

Neotype.—Determined by the writer, in the U. S. National Museum.

Zethus poeyi Saussure.

Zethus poeyi Saussure, Henri de, Rev. and Mag. Zool., vol. 9, 1857, p. 270; Smithson. Miscel. Coll., No. 254, 1875, p. 45-47.

Distribution.—Cuba. (Saussure). The National Museum has three specimens from Tavenier, Largo Key, Fla., collected by Frederick Knab.

Type.—Probably in the Museum of Geneva, Switzerland.

Zethus slossonæ Fox.

Zethus slossonæ Fox, W. J., Ent. News, vol. 2, 1892, p. 29-30.

Distribution.—Punta Gorda, De Soto Co., (Fox), Jacksonville, Duval Co., Miami, Dade Co., Fla.

Type.—Cat. No. 1855, U. S. National Museum.

HOLOLEPTINÆ OF THE UNITED STATES.*

By F. G. Carnochan.

Section I.

The Hololeptinæ in the United States comprise the genera *Hololepta*, subdivided into *Hololepta* and *Leionota* and *Iliotona* (n. gen.). The name Leionota, amended to Lionota by Marseul, requires comment. *Leionota* was proposed by Dejean as a genus of Histeridæ in the so-called first edition of his catalogue in 1821 (really the second); this division was retained in his catalogues of 1833 (the date usually assigned to the name), and 1837. Under this name he cited several species of which only two *Hololepta quadridentata* Fab. and *H. lamina* Payk. were described species; this citation would ordinarily fix the genus with one of the included described species as type, but Marseul in 1853 pointed out, after a study of the Dejean collection, that the species assigned by Dejean to *quadridentata* Fab. was not that species, but another which he described as *devia*, and that the species *lamina* was not Paykull's species but *minuta* of Erichson. The mere fact that the specimens which Marseul saw were misidentified does not invalidate the name. We have only published records to go by, and misidentification cannot be absolutely proved. Marseul in 1853 used the name *Leionota* for the same division, and in 1857 changed it to Lioderma. The name of the subgenus should therefore be Leionota and is ascribed to Dejean with a date of 1821 with *Leionota quadridentata* Fab. as type, as one of the forms included in the original citation, the name *Lioderma* becomes a synonym.

The life history and habits of the members of this subfamily are very little known. The egg is unknown, but probably closely resembles the eggs of the members of the other subfamilies; I have figured the egg of *Hister obtusatus* Harris (Pl. XXX, Fig. 3). This egg is similar in shape and appearance to the eggs of *Saprinus* and *Hetærius*, white, opaque and minutely roughened, about two millimeters long. Examination of the ovaries of various Histerids, and observations show that the eggs are ripened one at a time and are laid at appreciable

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University. No. 134.

intervals of time; in the genus Hister the interval varies from three to eight days, in Saprinus it is less, usually about one day. I append figures of the ovaries of *Hister obtusatus* Harris, *Saprinus pennsylvanicus* Payk. (Pl. XXX, Figs. 4-5), which show the periodic ripening of the eggs. The early stages of the larva are not known, but the last stage of Hololepta æqualis Say may be briefly described as follows:

Hololepta æqualis Say. Plate XXVIII, XXIX.

Larva. Wickham. American Naturalist, XXVIII, p. 816, 1894.

Length 14-16 mm. Flattened, white.

Head strongly chitinized, quadrate, chestnut brown. Dorsally, with a shallow transverse impression about one-third from the anterior margin to the posterior border, two punctures on this impression, behind them and out side of them two more, and behind these two and inside of them two more, a line connecting all these punctures would form an almost regular octagon; behind each antenna and forming the arc of a circle with the center towards the antennæ, three punctures. Clypeus quadrate, broader than long. Antennæ inserted posterior to the mandibles at the anterior corners of the head,* first external segment long, cylindrical, second a little more than half the length of the first, dilated at apex; third short, half the length of the second, narrowly cylindrical, the whole antenna almost as long as the head. Mandibles stout, curved, with a stout tooth a little more than halfway from the apex, on the inner margin; when closed the left mandible overlaps the right. Ventrally, the head has behind the labium a cordate shaped impression, at the anterior margin of which there is a boss, another boss occurs near the base, and connected to this impression at the base there is a deep spear-shaped puncture; near the lateral borders on a line with this puncture there is on each side a shallow puncture. Maxillæ inserted at the base of the mandible near the interior border, the dorsal surface of the first visible segment concave longitudinally; inner margin of the same segment fringed densely, outer margin lightly fringed and with a single long bristle on the apical fourth, second segment the

*Dissection shows the antenna to be inserted on a process next to the superior external basal corner of the mandibles, the true first joint. The antenna has four true joints.

length of first, one quarter the length of first, with a short segment on the inner margin which bears a single bristle. Third and fourth segments together a little longer than the second, and equal in length to the fifth, third segment slightly shorter than fourth. Labium with two jointed palpi, the first joint of which is half the length of the second. Pronotum as large as head, corneous with a deep median longitudinal furrow, the center portion, triangular, the base of the triangle towards head, deep chestnut brown, remainder light brown, a single bristle on each side before the middle. Prosternum corneous with seven differentiated areas, the center one triangular, with the apex of the triangle towards the head, yellow brown; on each side of this center area, a triangular area whose base is towards the head, of the same color, outside of this a rhomboidal area of lighter color, and posterior to the rhomboidal area, a white area which carries the coxæ.

Meso- and metathorax short, one-third the length of the prothorax. Mesonotum colored for its entire width, metanotum with a broad band for almost the entire width, and a smaller area at each edge, sternites with three markings; a broad band across the center to the lateral halves, and at each end of this band a smaller area, all colored light brown. Each segment with a single marginal bristle.

Nine abdominal segments are present, the first with two complete transverse rows of ambulacral hooks dorsally, and between each row the same arrangement of colored patches in threes as on the metathorax. All the remaining segments, except the ninth which bears none, have three rows of hooks, and between each row the same arrangement of plates. On the fold between the segments, on each side between the center and the lateral colored areas, there is a small group of hooks arranged in the arc of a circle whose center lies posterior; behind the last rows of hooks on the segments themselves and directly anterior to the small group mentioned above there is a single seta with a few hooks around it. Ninth segment with a pair of cerci, each composed of a basal tubercle which bears a single bristle, a first segment which is stout and clavate with a pair of stout bristles below the insertion of the second segment which is one and one-half times as long as the first segment, and half as wide, and bears at its apex a pair of strongly diverging bristles. On the lateral margins of the abdominal

segments are paired bristles, rising from tubercles, and on all the segments except the first there is, under the first of these bristles, another stout bristle on all the segments except the ninth where it is reduced in size and comes under the posterior bristle of the two, on the ventral surface. On the ventral surface each segment bears three rows of ambulacral hooks except the ninth which has none, and the eighth which has two complete rows, the first row broad and entire, the second short, interrupted at middle, the third entire and forked at each end. The ninth segment has the anal region developed into a pseudopod. Spiracles biforian, on the mesothoracic, and all abdominal segments except the ninth. Legs composed of a cylindrical coxa, which bears two bristles on its inner margin, a trochanter, cylindrical, short, a femur three times as long as the trochanter, a tibia two-thirds the length of the former and a claw; the claw bears a short accessory spine (visible only at high magnifications).

I am unable to see under the highest magnification the rudimentary tarsus which Schiodte (1864) figures. The spine on the claw resembles the figure given by Schiodte for *Platysoma depressum*. These larvæ have great difficulty in crawling unless they can bring the dorsum into contact with something. The hooks, which in the description I called "ambulacral," are used by the larva to push itself along. The larva, in moving, draws up the anal pseudopod and places it; then the segments move forward in rhythmical order, the hooks serving to attach each segment while the next one in front of it is moving forward. The larvæ are very voracious carnivores, living on the larvæ of an anthomyid fly, and an ortalid fly, eating from six to fifteen a day.

When the larva is full grown it sets itself to work to make the pupal cell, travelling as much as an inch for material, shredded wood, cotton, filter paper, anything available which it can chew up; the natural material is finely chewed wood. The wood is cemented together with an anal secretion, and it is not uncommon to see the larva reach to its anus with its head and apply the secretion gathered to the wall of its cell. I believe that the clypeus and frons are used for carrying the secretion and the clypeus and mandibles used as trowels to spread it. The larva begins by forming a ridge of transported material, then adds to the cell by adding pieces to each side

of the ridge. These are laid near the position desired and pushed into place with head and mandibles. Every little while the animal stops transporting material, wets the whole mass, pushing it into place with head and body. The last portion of the pupa case to be finished is the anterior end in which a small hole, through which the larva reaches its materials, is left till the last and is then plugged and cemented rather loosely. In one case the hole was not plugged at all, but remained open after the larva had assumed the prepupal position. When the cell is complete, the larva closes the open end and gives the entire inside of the cell a coating of the anal secretion, which is colorless when first applied, but rapidly becomes very dark brown; it then orients itself so that the head end of the pupa shall be opposite the loosely plugged opening; and takes a peculiar prepupal position. The body shortens slightly and the head is bent over and applied to the venter; this fold occurs at the suture between the metathorax and the abdomen. The time taken to become an immobile prepupa is about eighteen hours. The prepupal stage lasts seventeen-eighteen days; but the day before pupation takes place the prepupa raises the head and thorax slightly. The thorax then splits down the back and the pupa emerges.

Pupa: Length 8-10 mm. Color varying with age, but general appearance white. Imago visible through the transparent pupal skin. Spiracles on the second, third, fourth and fifth epipleurites. Genitalia extruded. On the pronotum, an irregular band of fifteen bristles extending distant from the margin along the lateral margin of the thorax to the hind margin half way from center to margin, and an inner row of three bristles. Elytra with scattered bristles, which are definite in number and location. (Pl. XXX, Figs. 1-2). Second, third, fourth, epipleurite each with a stout spine. First and second abdominal tergite with a pair of bristles, third with seven bristles (arranged in a triad and two pairs) each side of middle, fourth with two pairs and fifth with one pair each side of the median line. Propygidium and pygidium fringed with bristles. This chætotaxy is definite in the four specimens before me.

At the end of the second day after pupation the eyes are colored, by the eighth day the median line of the mesosternum and the median line and segment lines of the abdominal tergites

are colored. Pigmentation then commences on the pronotum and after twenty days the pronotum is fully colored. Emergence takes place at the end of from twenty-four to twenty-nine days. In one case emergence started at eight fifty-five in the morning, was completed except for the withdrawing of the genitalia at eleven fifteen, and was fully completed at twelve twenty-five. The adult does not become completely colored for three days after emergence.

Notes on the Morphology of Larva, *H. æqualis*, Last Stage. (Plates XXVIII, XXIX, XXX).

Head: Cranium (Figs. 5, 6, 7) symmetrical, rectangular, a little broader than long; occipital foramen narrower than the cranium and almost directly posterior, the head reaches slightly further back below than above; ventral surface with genal sutures (Fig. 6) apparent in the posterior portion. Labrum (Fig. 3) very rudimentary and slightly differentiated from the clypeus, not movable. Clypeus firmly united to frons, epistoma not distinct. Epicranial and frontal sutures not visible in living larvæ, though slightly visible in moult skins. Antennæ (Figs. 5, 6, 7) deeply inserted in the head. Above the dorsal articulation of the mandible, composed of four segments, the first very short, hardly visible externally, the second long cylindrical, the third capitate, a little more than half as long as the second, the fourth very small, cylindrical, the third joint with a sensory pit at the tip near the external margin, and one to three papillæ near the apex on the internal margin.

Mandible (Figs. 5, 6, 7) falciform, acute, with a single rounded tooth on the inner margin. At the base of the internal margin a cluster of setæ.

Maxillæ (Fig. 7) connected with hypostoma by a thin membrane. Cardo very small, almost completely concealed; a flat plate on the external border of the maxilla and fused to the stipes. Stipes, a long tubular segment, densely fringed with hairs on the inner margin, sparsely fringed on the outer margin, with a long tactile seta near the distal end, inserted just above the margin. The stipes are flattened on the dorsal side. Next to the stipes come a stout short segment, less than one-quarter the length of the stipes. It is swollen on the inner side and bears on the swelling a short finger-like segment,

which has a sensory bristle at the tip. The swollen segment probably represents subgalea and palpifer fused; the finger-like segment is probably galea. At the apex of this swollen segment is a three-jointed palpus. The second and distal segments of the palpus have numerous sensory pits on the surface.

The mentum is coriaceous, colored only on the margins; it is closely united to the submentum, which is slightly chitinized and light brown in color. The palpifers are fused and form a hollow tube, bearing two jointed palpi at the distal end. No ligula or paraglossæ are present. Above the labium lies the hypopharynx. This has two blades, visible in Fig. 7, which bear numerous bristles on the margin. Limiting the hypopharynx on each side is the hypostoma, which extends as a heavily chitinized rod upwards from the base of the mouth cavity, a flattened bridge, the epipharyngeal bracon (Fig. 7), extends between the two rods below the epipharynx (Fig. 3).

The thoracic segments are sharply differentiated from the abdominal. Pronotum consists of a heavily chitinized scutum, a less heavily chitinized parascutum. The meso- and metathorax show the scutum above. The first abdominal segment has a prescutum, a scutum and postscutum, the remaining abdominal segments have the scutum divided into two parts by a line of ambulacral hooks (reptoriæ Schiodte). On all the segments except the prothorax the pleuræ are readily distinguishable. On the dorsal side they are limited by muscle marks and on the ventral side there is a distinct sterno-pleural groove. The pleuræ are divided into epi- and hypopleuræ by the pleural suture. The epipleura of all the segments except the pro- and metathorax bears a biforian spiracle, and a bristle, the hypopleura bears also a single bristle. Prosternum consists of a triangular sternum and two plates on each side of it. The inner one is the parasternum, the outer is pleural in origin. The abdominal sternites show a presternum, a sternum which is cut off from the presternum by a muscle groove and a sternellum which is separated from the other two plates by a row of ambulacral hooks. The ninth abdominal segment bears an anal pseudopod, which I believe to be a tenth segment.

EXPLANATION OF PLATES—SECTION I.

PLATE XXVIII.

Fig. 1. Dorsal view of the larva of Hololepta æqualis Say.
Fig. 2. Ventral view of the larva of Hololepta æqualis Say.
Fig. 3. Underside of the clypeus showing the epipharynx (larva of H. æqualis).

PLATE XXIX.

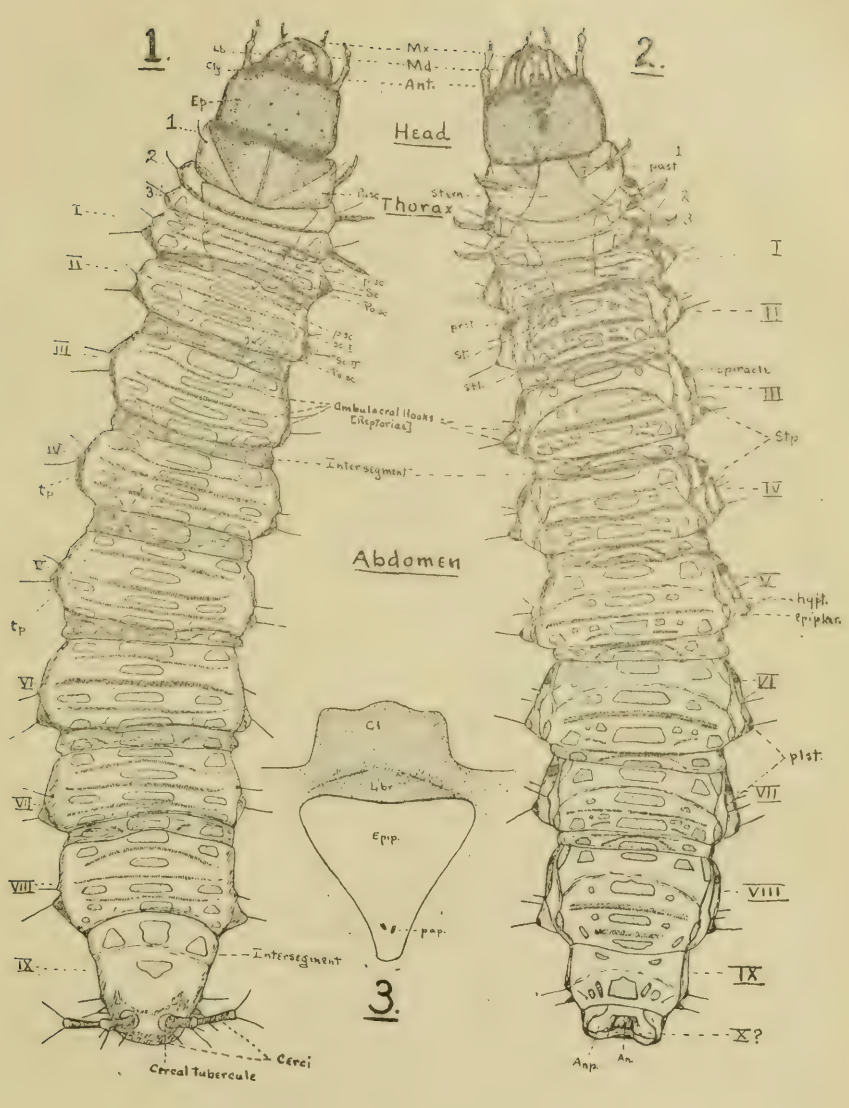
Fig. 4. Lateral view of the larva of H. æqualis.
Fig. 5. Dorsal view of cranium.
Fig. 6. Ventral view of cranium.
Fig. 7. Half front, half ventral view of mouth. Hypostoma and epipharyngeal bracon shown in stipple.

PLATE XXX.

Fig. 1. Ventral view of the pupa of H. æqualis.
Fig. 2. Dorsal view of same.
Fig. 3. Egg of Hister obtusatus Harris. × 12.
Fig. 4. Ovaries of Saprinus pensylvanicus Payk.
Fig. 5. Labium of *H. æqualis*.
Fig. 6. Ovary of Hister obtusatus Harris.

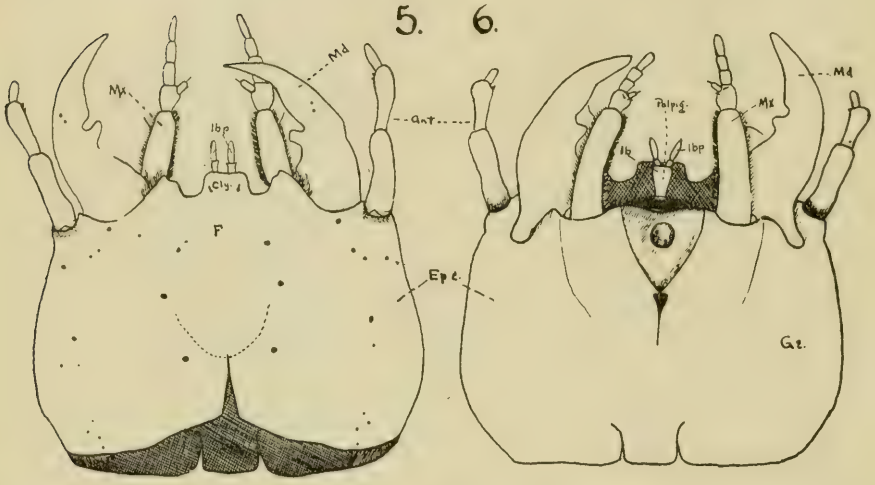
EXPLANATION OF TERMS USED ON PLATES XXVIII—XXIX.

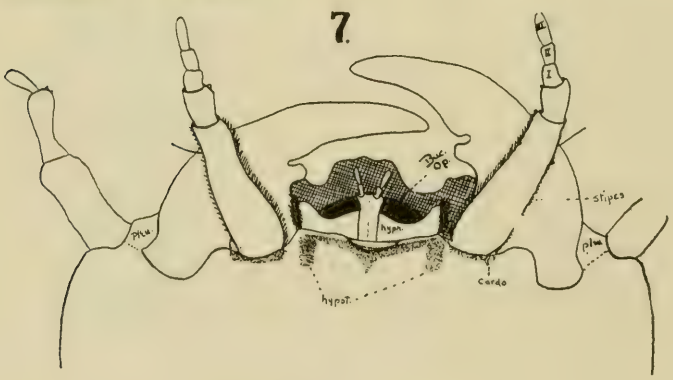
Mx—Maxillae.
Md—Mandibles.
Ant—Antennae.
Lb—Labium.
Cly—Clypeus.
1, 2, 3—Thoracic segments.
I–IX—Abdominal segments.
Pasc—Parascutum.
p. sc—Prescutum.
sc—Scutum.
po. sc.—Postscutum.
past—Parasternum.
prst—Presternum.
st—Sternum.
stl—Sternellum.
stp—Sterno-pleural fold.
plst—Pleural suture.
hypl—Hypopleurite.
epipleur—Epipleurite.
Lbr—Labrum.
Epip—Epipharynx.
pap—Papillae.
F—Frons.
Epic—Epicranium.
Ge—Genae.
lbp—Labial palpus.
Palpig—Palpiger.
Buc. Op—Buccal opening.
hyph—Hypopharynx.
hypst—Hypostoma.
pleur—Pleurostoma.



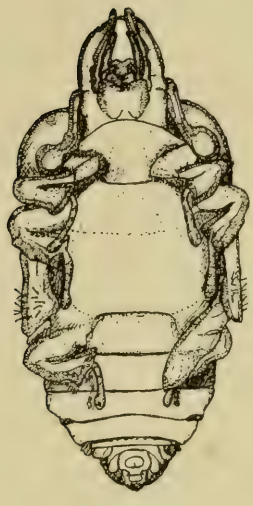
F. G. Carnochan.







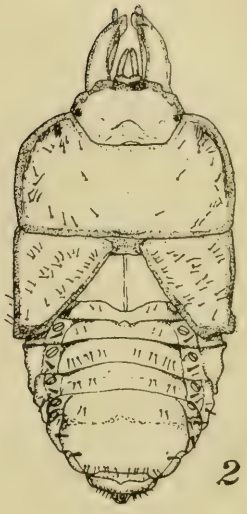
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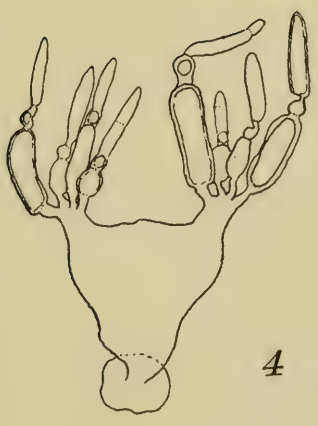
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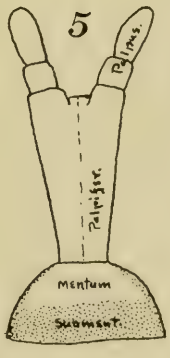
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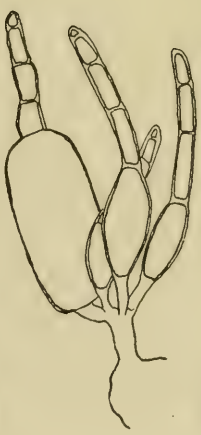


2



4





6

F. G. Carnochan.

SECTION II.

The species of *Hololeptinæ* are all black, elongate and more or less flattened, with a large projecting head which is more or less retractile, but not depressible; the mandibles are long and projecting, subequal and not crossing, except in *Oxysternus*, in which the left mandible is longer than the right and crosses it when closed. Labrum short, arcuate on each side of the median notch, viewed from above; excavated in front from below; closes the mouth by being applied to the anterior edge of the mentum, into the emargination of which it exactly fits; the maxillæ are inserted behind the mentum, their palpi lying in grooves on the mandibles. The prosternum is unlobed, although in certain of the genus *Hololepta* there is an impressed line dividing the prosternum into two parts, the anterior of which simulates a lobe. The propygidium is horizontal, or slightly depressed.

KEY TO THE NORTH AMERICAN HOLOLEPTINAE.

Prosternum not carinate, rounded or truncate anteriorly. Teeth on middle and hind tibiae unequally spaced, the two lower arising from the same process, more distant from the upper than from each other. Genus **Hololepta**
Prosternum flattened, broadly rounded anteriorly.....Subgenus **Hololepta**
Prosternum elevated, narrower at apex and often truncate..Subgenus **Leionota**
Prosternum carinate, terminating apically in a sharp point. Teeth of hind and middle tibiae, rising from different processes, equally spaced, long, spiniform **Iliotona** n. g.

Genus **Hololepta** Payk.

Elongate, flattened. Head porrect, mandibles subequal. Tibiæ dentate, the anterior quadri-, posterior and intermediate tridentate, the two lower teeth of the intermediate and posterior tibiæ borne on the same process, closer to each other than to the upper tooth; on the intermediate tibiæ there is also, in some species, a small additional tooth at the base of the upper and middle crests.

SUBGENUS HOLOLEPTA.

Strongly depressed, elongate. Prosternum very broad and flat; anterior margin broadly rounded. A fovea-like impression behind the eyes; supraorbital stria entirely lacking. In our forms there is always a transverse line on the prosternum about one-third of the distance from apex to base.

KEY TO HOLOLEPTA.

1. Elytra without entire striae; prosternal apex slightly emarginate; lateral pronotal punctures sparse, indistinct or absent.....2.
 Elytra with an entire stria; prosternal apex broadly and evenly rounded; lateral pronotal punctures coarse, in a distinct band.....**lucida** Lec.
2. Elytra without an apical appendix to second stria, tristriate; pygidial punctures large; inflexed portion of elytra not rugose; prosternum not punctate.....**aequalis** Say.
 Elytra with an apical appendix to the second stria, bi- or tristriate; pygidial punctures fine and sparse; inflexed portion of elytra slightly rugose; prosternum finely punctate.....3.
3. Narrowly oblong, almost parallel; upper surface impunctate, (except under extreme magnifications); propygidium not bifoveolate.....**populnea** Lec.
 More narrowly oblong than preceding; upper surface distinctly punctate with minute punctures; propygidium bifoveolate at apex...var. **punctata** nov.

Hololepta æqualis Say. Trans. Amer. Phil. Soc. V, p. 47. 1825.
fossularis Say. Trans. Amer. Phil. Soc. V., p. 47. 1825.
fossularis ♂ Mars. Mon. p. 147, t. 4, fig. 5. 1853.

Elongate, oblong, almost parallel. Front flat, smooth, without striæ; preocular tooth not prominent. Mandibles as long as the head (♂), slightly shorter (♀), stout. Pronotum very slightly bisinuate at base, with a median longitudinal stria half extending from base half way to apex; marginal stria strong, entire, slightly sinuate behind the middle; sides of pronotum distantly and sparsely punctate, distant from margin. Elytra the width of pronotum, narrowing slightly posteriorly; tristriate, the first stria about one-third the length of the elytra, the second about one-third the length of the first, the third a trace, sometimes barely visible; sub-humeral deep, almost reaching the base, abbreviated at apex on the apical sixth. Inflexed border of the elytra impunctate. Propygidium smooth on disk, laterally bordered with sparse, coarse punctures. Pygidium usually evenly, rather sparsely punctate, but occasionally varying to smooth at middle and apex. Mentum transversely concave (♂), slightly concave with the center raised (♀), sparsely punctate. Gula with a broad V-shaped excavation (♂), with a small impressed V (♀). Prosternum broad, apex truncate, margin slightly emarginate. Length (apex of thorax to apex of suture*) 5–6 mm.

Variant forms. Three specimens in my series vary from the typical form by the presence of a very short apical appendix to the first stria.

New York to Michigan and Eastern Kansas, south to Florida, Texas and Louisiana.

*This system of measuring, which gives a constant measure, and is not affected by the retractility of the head and propygidium, will be used throughout this paper.

The amount of punctation on the margins of the thorax varies from a very few distant punctures to an appreciable number, always, however, distant from the lateral margin.

The males may be readily distinguished from the females by the large fossa at the anterior angles of the thorax.

This species occurs under the bark of dead *Liriodendron* and is reported by Marseul to occur under the bark of *Robinia pseudo-acacia*.

It is rather unfortunate that the name *æqualis* must be substituted for the well-known name *fossularis*, but our present laws of nomenclature take cognizance of page priority and the name *æqualis* stands first on the page. Marseul, who first detected the fact that *æqualis* and *fossularis* were opposite sexes of the same species used the male name as was the custom at that time, but in this case also the International code is definite and the earlier name must be used.

Hololepta lucida. Leconte, J. Mon. p. 7, pl. 1, fig. 2. 1845.
Marseul, Mon. p. 177, pl. 4, fig. 18. 1853.

Elongate oblong, almost parallel. Front flat, without striæ; preocular tooth not prominent. Mandibles as long as head (♂) or slightly shorter (♀), stout. Pronotum very slightly bisinuate at base, with a median longitudinal stria extending half way from base to apex; marginal stria strong, entire, slightly sinuate behind the middle; distinctly punctate laterally in a broad band, in which the punctures often coalesce to form vermiform punctures. Elytra the width of the pronotum at base, slightly arcuate; tristriate usually, the first stria entire, the second short, with or without a short apical appendix, the third punctiform or absent; subhumeral abbreviated at base and apex. Inflexed border of elytra impunctate. Propygidium smooth on disk, laterally bordered with extremely coarse, sometimes vermiform punctures, bifoveolate at apex. Pygidium coarsely, densely punctate. Mentum transversely concave (♂), slightly concave with center elevated (♀), very finely, sparsely punctulate. Prosternum broadly evenly rounded at apex. Length 4.5–6 mm.

New York to Southern Illinois, south to Virginia.

The form with the short apical appendix to the second stria is the form described by Leconte. The males may be recognized by the fossa in the anterior angles of the thorax.

Reported by Blatchley (1910) under cotton wood bark.

Hololepta populnea Leconte. Ann. Lyc. N. York, V., p. 163. 1851.
bractea Er. Marseul. Mon. p. 157, t. 4, fig. 15. 1853 (in error).
populnea Marseul. Mon. p. 562, pl. II, fig. 5. 1850.

Narrowly oblong, nearly parallel. Front without striæ, preocular tooth short. Mandibles as long as the head (♂) or slightly shorter (♀). Pronotum bisinuate at base, with a more or less lightly impressed median stria, extending half way from base to apex; marginal stria entire, strong slightly sinuate behind middle, or interrupted or with the entire posterior half lacking. Elytra the width of pronotum at base, parallel; bi-or tri-striate, the first stria short, about one-third the length of elytra, second shorter, one-half the length of the first with a short apical appendix, third punctiform or absent; subhumeral stria deep, abbreviated slightly at base and apex. Inflexed border of elytra slightly rugose. Propygidium smooth on disk, extremely sparsely punctate laterally with deep punctures. Pygidium very finely and sparsely punctulate. Mentum concave (♂), less concave (♀), sparsely punctulate; gula with a broad V-shaped excavation, which has a short longitudinal carina at the base (♂) or with a small V-shaped impression (♀). Prosternum broadly emarginate at apex, finely punctulate. Length 3.5–5 mm.

Utah, Arizona, southern California and New Mexico.

Variants. The typical form as described by Leconte has the marginal stria of the thorax entire, and all the Leconte types have such a marginal stria; many of the specimens which I have examined have the stria more or less interrupted; in the extreme form the posterior half of the stria is absent; every possible intergrade is present in my series, even one in which the stria is broadly interrupted on one side and strong and entire on the other.

The length of the apical appendix also varies, in some it is extremely short and in one it is connected to the second by two punctures. The propygidial sculpture also varies, usually in proportion to the length of the apical appendix, but the correlation is not perfect.

One specimen agrees fairly well with Marseul's description of *H. bractea* Erichson in having the appendical stria directed towards the first stria and in pygidial sculpture. Marseul, in his first description (1853) of *bractea* reported it from the United States, and placed *populnea* in synonomy with it. He had at that time not seen the type of *bractea*. In a later description (1860) made after he had seen the type *bractea*, and had received specimens of *populnea* from Leconte, he states that the two species are distinct. I hesitate to assign the

specimens above mentioned to *bractea*, because of the recorded variation in the punctation of the propygidium, and the fact that in size and facies the specimen is *populnea*.

The males may be distinguished by the notch in the anterior angle of the thorax, and the greater excavation of mentum and submentum.

Reported by Leconte (1851) under poplar bark; by Horn (1873) between the layers of cotton-wood bark.

Hololepta populnea var. **punctata** nov.

More narrowly elongate than *populnea*, almost parallel. Front without striæ, punctate with fine punctures, preocular tooth short depressed. Mandibles shorter than head (♀) (♂). Pronotum bisinuate at base, with a slightly impressed median stria extending half way from base to apex; marginal stria entire not strongly impressed, slightly sinuate behind middle, or interrupted; distinctly punctate with punctures of same magnitude as those on front and mandibles. Elytra the width of pronotum at base, narrowing slightly towards apex, bistriate, the first stria short, about one-third the length of the elytra, second half the length of the first, with an appendix in the apical third; subhumeral stria abbreviated at base and apex. Inflexed border of elytra slightly rugulose. Propygidium minutely, distantly punctulate on disk, laterally bordered with sparse larger punctures, which are larger than those of *populnea*, slightly bifoveolate apically. Mentum, gula and prosternum as in *populnea*. Length 4 mm.

Arizona, one male and one female. W. M. Mann. Sexes are differentiated as in *populnea*.

Hololepta (Hololepta) **excisa** Mars.

This species is recorded from the United States by Marseul. I have seen no specimens taken in the United States, and do not believe that this species occurs north of Mexico. It is reported from Mexico(Marseul, Biologia), Costa Rica (Biologia), Venezuela, New Granada, and Brazil (Marseul), I append an abstract of Marseul's description.

Oblong, subdepressed, shining black. Front flat, without striae or tubercles. Pronotum punctate laterally, marginal stria scarcely angulate, well marked. The inflexed border of the elytra strongly rugose; subhumeral stria strong, rugose, a little abbreviated at base; dorsal striae two, rudimentary. Propygidium bordered with distant punctures. Pygidium densely and strongly punctate. Anterior tibiae armed with four blunt teeth; posterior with three long spines.

The males are characterised by the excavation of the mentum and the notch in the anterior angle of the pronotum.

Hololepta bractea Erichson, Klug's Jahrb. Ins., p. 91. 1834.
Marseul, p. 157, t. 4, fig. 15. 1853.
Marseul, p. 591 (t. 11, fig. 4). 1860.

In connection with the earlier description Marseul lists this species from the United States, because he had confused the species with *populnea* Lec. Lewis, in his Catalog of the Histeridæ (1905) cites this species from California, evidently on the strength of Marseul's first description, and makes no mention of Marseul's second description which refers the species to New Granada. Bickhardt in Junk's Catalogus Coleopterorum, *Histeridæ*, (1910) copying from Lewis, makes no change in the record or addition to the reference. I doubt the occurrence of this species in the United States.

Hololepta complanata P. deBeauv. Ins. Af. et Am., p. 176, t. 6, fig. 5, 1807.
Lew. Ann. Nat. Hist. XVI, p. 206. 1885.

Lewis and Bickhardt record this species as from North America, a form of citation which usually means north of Mexico. The species was recorded originally from Santo Domingo, and is unidentifiable in North American material.

SUBGENUS LEIONOTA.

Subdepressed, elongate. Prosternum elevated, more or less compressed laterally, narrowed, and anteriorly truncate or rounded at apex. Impression behind the eyes not distinctly limited; supraorbital stria usually visible at base.

The two subgenera of Hololepta are not very well limited, and in many cases a species might be placed with equal propriety in either.

KEY TO LEIONOTA.

1. Pronotum with a short impressed line on each side of the emargination at the apical margin, behind the eyes. Larger species.....2.
 Pronotum without a short impressed line on each side of the emargination. Smaller species.....4.
2. Broadly oblong. First and second elytral striae not continued towards scutellum along basal margin. Sternites of abdomen punctate at sides only. Lower crest of fore tibiae not dentate.....3.
 Narrowly oblong. First and second elytral striae continued along basal margin almost to the scutellum, this stria occasionally interrupted. Sternites of abdomen punctate throughout. Lower crest of fore tibiae dentate.....**pervalida** Blais

3. Pygidium densely and coarsely punctate. Usually with an appendix to the second elytral stria.....**yucateca** Mars.
Pygidium finely punctate. Never an appendix to the second stria.....
princeps J. Lec.

4. Sides of thorax moderately coarsely punctate. Mentum without an M-shaped excavation.....5.
Sides of thorax impunctate. Mentum with an M-shaped excavation.....7.

5. Front without strioles, or the strioles short, feeble and widely separated. Species broadly oblong.....6.
Front with at least two closely approximated, long arcuate striae. Narrowly oblong.....14.

6. Front without strioles. Larger 6.5–7 mm.....**vernicis** Casey.
Front with widely separated, short, feeble strioles. Smaller 5.5–6 mm.
sirpus sp. nov.

7. Second dorsal stria of elytra interrupted in the basal third..**interrupta** Mars.

8. Elytra with a stria on the basal margin more or less deeply impressed, besides the two dorsal striae.....9.
Elytra with but the two dorsal striae.....**quadridentata.** 10.

9. Elytron with a deeply impressed, transverse stria along the basal margin equidistant from the second longitudinal stria and the scutellum.....
decimstriata sp. n.
Elytra with an area, roughened by three longitudinal lines, between the second dorsal stria and the suture. From this area, a very faint finely impressed line extends along the base almost to the scutellum. On each side of the scutellum is a narrow, deep fovea.....**bifoveolata** sp. n.

10. Front with two shallow foveae. Supraorbital stria long, reaching almost halfway to the tip of the preocular spine. Head extremely minutely punctulate*.....subsp. * **platysma** Er.
Front without foveae, supraorbital stria short.....11.

11. Propygidium not at all, or extremely sparsely punctate on disk. Males with the thoracic fossa deep, and well marked.....12.
Propygidium distinctly punctate on disk. Males with the thoracic fossa poorly developed and very shallow.....subsp. **minor** nov.

12. Pygidium evenly punctate, the space enclosed by four punctures equal in size to a puncture. First elytral stria closer to the second than to the margin.....13.
Pygidium unevenly punctate, the space enclosed by the four punctures being less than half the size of a puncture. First stria midway between second and margin.....*subsp. **quadridentata**

13. Marginal stria of thorax without sinuation.....subsp. **floridae** nov.
Marginal stria of thorax with a shallow semi-circular sinuation just before the middle, and below this on the margin itself a short impressed line..
floridae var. **striatifera** nov.

14. Gula with a carina on each side extending backwards from the mandible, elevated in the anterior half, low and interrupted in the posterior half, the two carinae forming a V. Prosternum narrowly truncate at apex. **vicina.** 15
Gula without carinae, but with a Y-shaped groove. Prosternum broadly truncate, its anterior margin elevated and rugulose.....**caseyi** sp. n.

15. Larger 6 mm. Second, third and fourth abdominal sternites punctate for their entire width.....subsp. **neglecta** Blaisd.
Smaller 4.5–5 mm. Second abdominal sternites punctate at sides only, third and fourth punctate in a narrow band across the middle of disk.....16.

16. Third elytral stria a puncture.....**vicina** Lec.
Third elytra stria as long as the first.....**vicina** var. **californica** nov.

*Denotes a form not occurring in the United States.

Hololepta (Leionota) princeps. Lec. J. Proceedings Acad. Nat. Sci. Phil., p. 310. 1859.

Marseul, Mon., p. 605. 1860.

Horn. Pro. Amer. Phil. Soc., p. 274. 1873 (in error).

Oblong, rather broad. Front without strioles or depressions; preocular tooth slightly prominent, depressed, supraorbital stria long, distinct. Mandibles slightly longer than head, not striate at base; stout. Pronotum strongly bisinuate at base, with a fine median longitudinal stria extending from the base slightly past the middle; marginal stria entire, rounding the anterior and posterior angles, rather sharply broadened in the anterior half; two short striæ near the anterior margin behind the eyes. Elytra the width of pronotum at base, arcuate on the sides, slightly longer on the suture than the median length of the pronotum; apical angle broad and rounded; bistriate, the first stria short, about one-fourth the length of the elytra, the second very short, without a trace of an apical appendix; subhumeral abbreviated at base and apex. Inflexed portion of elytra rugose. Propygidium impunctate on disk and apex, laterally bordered with a narrow band of punctures which are of two sizes, larger and very sparse on the basal half, finer and slightly more numerous on the apical half. Pygidium finely punctate in an irregular band across the disk, smooth at base and apex, punctures usually separated by twice their own diameter but irregular in distribution. Mentum flat, punctate. Prosternum elevated, truncate at apex. Lower crest of hind tibia not dentate. Length 10 mm.

Distribution. Cahon Pass, California. (Tejon Pass, Cal., Lec.).

This species is distinct from *yucateca*, with which it had been synonomized by Horn (1873), being very much broader, and with the punctation of the propygidium and pygidium sparser and finer. Although *yucateca* occasionally has no apical appendix to the second stria, it is readily separable from *princeps* by the characters given above.

In the Leconte collection in the Museum of Comparative Zoology, there are three specimens, the first of which bears the label *H. princeps* Lec., with the locality Cajan Pass, California. All three specimens are identical. Whether these are the veritable types or not is impossible to say, as the species was described by the elder Leconte, who, so Dr. Schwarz tells me, was accustomed to send his specimens to Count Dejean. Some of his species, however, but which ones we do not know, probably found their way into the collection of his son. I shall consider these specimens as types as they agree with the original description fairly well. The greatest point of

divergence between the specimens and the description is in the punctation of the pygidium; the description states that the pygidium is "sat dense" punctured; it is not as densely punctured as the pygidium of *yucateca*, which Marseul says is "densement et assez fortement ponctué." If one had seen *yucateca*, the term dense, even modified, would not be applied to the punctation of the pygidium of *princeps*, as the punctures are in many places separated by from two to four times their own width.

Hololepta (Leionota) yucateca Marseul, Mon., p. 203, t. 5, fig. 1. 1853.
grandis Marseul, Mon., p. 204, t. 5, fig. 2. 1853.
synonomy Marseul, Mon., p. 606. 1860.
Horn, Pro. Am. Phil. Soc., p. 274. 1873.

Broadly oblong. Front with two extremely slight depressions, which may or may not have very lightly impressed striæ at their bottoms; preocular tooth slightly prominent, depressed, supraorbital stria long, distinct. Mandibles longer than the head (♂) or equal in length to the head (♀), stout, usually with a short stria on the upper surface, near the external margin and base. Pronotum bisinuate at base, with a median, longitudinal stria, more or less lightly impressed, extending from the base past the middle; marginal stria entire, rounding the posterior angle, and terminating in a more or less deep fossa close to and behind the anterior angle, rather sharply broadened anterior to the middle (♂) or gradually slightly broadened (♀); two short striæ near the anterior margin behind the eyes. Elytra bistriate, the outer strong, deeply impressed, usually about one-third the length of the elytra, second shorter, usually with an apical appendix of varying length; subhumeral stria abbreviated at base, slightly abbreviated at apex. Inflexed portion of elytra rugose. Propygidium with disk smooth, laterally punctate with a band of moderately coarse punctures which are coarsest near the base; apex very finely punctate. Pygidium densely and coarsely punctate, punctures separated usually by less than their own diameter. Mentum slightly concave, punctate. Prosternum truncate at apex, elevated, punctulate. Ventral segments of abdomen punctate at sides only. Lower crest of fore and hind tibiæ not dentate. Length 8–10 mm.

Distribution. Southern California, New Mexico, Arizona and Texas.

Variants. This species may have the second stria entire, more or less widely interrupted, or with the apical appendix reduced to a very faint line, a series of shallow punctures, or entirely lacking.

The supraorbital stria may be narrowly interrupted at about its middle. The punctation at the sides of the pygidium may coalesce to form a well defined stria of varying length, depending on how many punctures are involved. This stria is always near the base of the pygidium.

The males are usually but not always narrower, and more elongate than the females; their mandibles are longer in proportion to the length of the head, and the thoracic marginal stria is more strongly dilated in the apical half. The length of the stria appendicular is not correlated with sex, and *yucateca* and *grandis* while opposite sexes, are not so because of the length of the appendicular stria, but because of their shape. *Yucateca* is probably the female and *grandis* the male, contrary to what Horn says.

This species is reported from decaying Cereus; in the fruits of Cucurbita, *Echinocactu viridescens*, and in the leaves and stalks of *Opuntia occidentalis* (Fall, 1901).

Hololepta yucateca is very variable and the species as now accepted may be made up of several different elements. Facies, length of mandibles, supraorbital stria, sculpture of front, length of subhumeral stria, length of second stria and its appendix are all variable, but I have been unable as yet to find correlations in any of these characters. The form which has no apical appendix to the second stria closely resembles *princeps* of Leconte in size and facies, but is easily separated from the latter by the punctation of the pygidium.

Hololepta (Leionota) pervalida Blaisdell Zoe III, p. 327. 1892.
Hololepta pervalida Lewis, Ann. Nat. Hist., XIV, p. 139. 1904. (to consider *pervalida* a Mss. name).
pervalida Lewis Catalog., p. 3–5, 1905.
pervalida Schaeffer, Ent. News, XVIII, p. 301, 1907.
pervalida Lewis, Ann. Mag. Nat. Hist., XX, p. 96. 1907.

Narrowly oblong. Front with two mammiform elevations which are delimited by a fine impressed line, deepest at apex, behind the mandibles. In the basal portion of the delimiting line on each side lies a stria which is composed of a series of punctures, and posterior to the stria is a sparsely punctured area which extends across the front, weakest in the center. At the apex of the front in the groove between the elevations there is a small tubercle in the male. Preocular tooth strong, slightly depressed. Supraorbital stria distinct, of varying length, often interrupted. Mandibles stout, carinate, upper margin

carinate, broadly curving, as long as the head. Pronotum slightly bisinuate at base, with a strongly impressed median dimidiate longitudinal stria; marginal stria strong, extending around posterior angles, sharply broader anterior to the middle and terminating in a large fossa (♂), gradually widening and terminating in a small fossa (♀), at some distance behind the anterior angles; anterior to the fossa, the surface of the pronotum is rugose and from this rugose area, a fine stria extends along the anterior margin to a point behind the eye; posterior to this stria there is a short broadly impressed stria, which extends beyond the marginal about one-half its own length; margin of pronotum with the marginal stria irregularly punctate, most densely just posterior to the fossa, the punctures more sparse posteriorly and extending along the posterior margin half way to center. Elytra bistriate, the first short, about one-third the length of the elytra, continued along basal margin to the second, with which it sometimes connects, continued to the apex by a series of distant punctures; the second stria entire, and continued along basal margin of elytra almost to the scutellum; subhumeral deep, abbreviated at base under humerus, but sometimes continued almost to the base by a few punctures. Elytra distinctly punctured towards apex. Inflexed portion of elytra rugose. Propygidium coarsely and fairly evenly punctate, most coarsely at lateral margins. Pygidium coarsely but not very densely punctate. Mentum slightly concave, densely, strigosely punctate laterally and at corners, sparsely punctulate at center. Prosternum elevated, constricted in apical fourth, slightly depressed anterior to the constriction, and again elevated at apex, truncate. Ventral segments of abdomen punctate throughout. Lower crest of fore tibiæ dentate. Length 8–9 mm.

Distribution, San Diego, Co., Pasadena, California.

Variants. The second stria of the elytra is not connected with the marginal at base, is punctiform and broadly interrupted.

The males may be told from the females by the shape of the anterior fossæ and the width of the marginal striæ. In the males the fossa has the internal margin sinuate, and the marginal stria broadens suddenly towards the fossæ at about its middle. This broadening of the marginal stria causes the male thorax to look less punctate than the female thorax as part of the band of punctures lies in the broadened portion of the stria. Just before the stria enters the fossa it cuts under the edge of the fossa so that a small tooth projects over the stria, thus causing the inside margin of the fossa to appear sinuate.

Reported to occur in Yucca whipplei (Fall.) and Echinocactus (Blaisdell).

Hololepta (Leionota) vernicis Casey. Ann. N. Y. Acad., VIII, p. 534. 1893.

Lewis, G. Cat., p. 5, 1905 (synon. in error).
Schaeffer, Ent. News, p. 302. 1907.
Bickhardt, Cat., p. 8. 1910 (synon. in error).

Elongate, oblong. Front without strioles; preocular tooth slightly prominent; supraorbital stria very short basal. Mandibles slightly longer than head (♂), or equal in length to head (♀). Pronotum bisinuate at base, with a median, dimidiate, longitudinal stria, lightly impressed; marginal stria entire, deeply impressed, rounding the posterior angles, and ending anteriorly in deep, triangular fossa (♂) or a short hook (♀); punctate sparsely in a narrow band within the marginal stria, the punctures closer and more numerous basally. Elytra bistriate, the first about one-third the length of the elytra, the second about one-half the length of the first, with an appendix extending from the basal fourth almost to the apex; subhumeral stria deeply impressed for most of its length, the basal part fine and reaching almost to the base (♂) or a little shorter (♀). Inflexed portion of elytra rugulose. Propygidium smooth on disk, coarsely punctate laterally, finely punctulate at apex. Pygidium coarsely and densely punctate. Mentum concave (♂), almost flat (♀) evenly punctate. Prosternum elevated, truncate at apex. Ventral segments punctate at sides only. Lower crest of fore and hind tibiæ not dentate. Length 6.5–7 mm.

Distribution, Arizona (type). Huachuca Mts., Arizona (Schaeffer).

Santa Rita Mts., (Schwarz and Barber) Oracle, Arizona.

Variants. One male has a small stria which is attached basally to the appendix of the second stria at an obtuse angle, and so prolongs the appendix that it almost reaches the second stria.

Two specimens have an entire second stria on one side, the other side normal.

The male is slightly broader than the female, has a large deep fossa at the anterior angle of the pronotum, a differently shaped mentum and a longer subhumeral stria.

Reported to occur in dying *Dasyllirion* (Schwarz) and *Agave americana?* (Schaeffer).

Hololepta (Leionota) sirpus sp. nov.

Broadly oblong. Front feebly bistriate, the stria widely separated; preocular tooth moderately prominent; supraorbital stria, basal, short. Pronotum with a lightly impressed median stria extending from base half way to apex; punctate laterally in a narrow band of large, distant punctures; marginal stria entire strong, rounding the posterior angle

and extending to a point opposite the second dorsal stria, ending anteriorly in a triangular fossa (♂), or just turning the anterior angle (♀). Elytra bistriate, the first basal slightly more than one-third the length of elytra, second shorter with an apical appendix which reaches past the tip of the first stria and is curved inward at the base; in addition there is short stria outside the first on the humerus; subhumeral stria abbreviated under the humerus at base, and abbreviated at apex. Propygidium bifoveolate at apex, coarsely, moderately densely punctured on the lateral thirds, finely punctate at apex, disk smooth. Pygidium densely and coarsely punctured. Mentum excavated (♂), almost flat (♀). Prosternum elevated, broadly rounded at apex, with an impressed line at the apical fourth. Length: Male, 6 mm.; female, 5.5 mm.

Type ♀. Ramsey Canon, Huachuca Mts., Arizona (W. M. Mann).

Paratype ♂. Mexico.

Hololepta (Leionota) quadridentata. Fal. Ent. Syst. I, p. 74. 1792.

quadridentata (platysma Erisch.) Paykull. Mon., p. 109, t. 9, fig. 4. Larva t. 1, fig. 3 (in error). 1811.

Marseul. Mon., p. 212, t. 5, fig. 10. 1853. p. 608. 1860.

Perris. Insectes du Pin. Maritime. Col. I. (Larva) 1863, p. 123–124.

H. flagellata. Kirby, Trans. Linn. Soc. Lond. XII, p. 395. 1818.

Lewis, Ann. Mag. Nat. Hist., XV, p. 458. 1885.

H. surinamense. Habst. Kaf. IV, p. 51. 1791.

Oval. Front without strioles; preocular tooth moderately prominent, mandibles as long as head. Pronotum markedly bisinuate at base; marginal stria entire extending around the posterior angles to a point opposite the second elytral stria, deeply impressed, except for the portion on the posterior margin of the pronotum which is fine. Elytra bistriate, the first stria short about one-third the length of the elytra, the second entire, slightly arcuate. Subhumeral moderately deep, rugose, extending from apex four-fifths to base. Inflexed portion of elytra not rugose. Mentum slightly concave with an M-shaped excavation which makes the mentum appear carinate. Prosternum elevated, truncate at apex.[1], [2]

[1]**Hololepta quadridentata** Payk. Mon. p. 109, t. 9, fig. 4, 1811.

Erichson, Klugs. Jahrb. Ins., p. 95. 1834.

Marseul. Mon., p. 212. 1853.

Front with two shallow elongate foveæ, these foveæ divide the head into thirds, and extend longitudinally from the posterior third to the anterior third of the front. (fig. –). Supraorbital stria long, reaching a point almost half-way to the tip of the preocular spine. Front minutely punctate under high magnifications. Pronotum with an extremely

faint median dimidiate stria; surface minutely punctulate under high magnifications. Elytra with the first dorsal stria midway between the second and the margin, second stria evenly arcuate. Propygidium appearing smooth on the disk (under high magnifications extremely finely and minutely punctulate), punctate laterally, the punctures coarse, becoming finer towards base, center, and finest but distinct along the apical fourth. Pygidium evenly, moderately coarsely and not very densely punctate, the space enclosed by four punctures being equal in size to one puncture. Visible portion of dorsal segment anterior to the propygidium coarsely and densely punctate. Length 5.75 mm.

Distribution, Peru and Brazil.

[2]Subspecies **quadridentata** Fab.

Front without strioles or foveæ, noticeably punctate, more densely than in the preceding; supraorbital stria extremely short, extending at most less than one-third to tip of preocular spine. Pronotum punctate, more noticeably so than in the preceding. Elytra with the dorsal striæ almost as in the preceding, but the second dorsal has a slight uneven sinuation opposite the apex of the first dorsal. Propygidium less punctate than the preceding, the punctures more widely spaced, and the apex appears smooth. Pygidium unevenly punctate, the lateral punctures twice as large as in the preceding, and more dense, the space enclosed by four punctures being less than half the size of a puncture; punctation finer and more distant at the center. Visible portion of the segment anterior to the propygidium as in the preceding.

Male with the anterior fossa of the thorax well marked.

Length 5.5–5 mm.

Distribution, Mexico.

Subspecies **floridæ** nov.

Head and pronotum as in *quadridentata* but not more punctate than typical form. Elytra with the first dorsal stria closer to the second dorsal than to the margin; second dorsal as in the preceding subspecies. Propygidium with the punctures distributed as in subspecies *quadridentata*, but more densely punctate laterally, and sometimes with a very few occasional punctures on the disk. Pygidium with the punctures spaced as distantly as in the typical subspecies, but diminishing in size towards the center as in *quadridentata*. Visible portion of the segment anterior to the propygidium with slightly larger but fewer punctures than the preceding.

Male with the anterior fossa of the thorax well developed, and deep.

Length 5–4.25 mm. 13 males, 14 females.

Type, allotype and paratypes in my collection.

Distribution, Enterprise, Indian River, Biscayne, Jupiter, Haulover, Florida.

The three preceding have the propygidium more convex and longer in proportion to its width than the following subspecies:

Subspecies **minor** nov.

Front, and pronotum punctulate as in typical subspecies. Supraorbital stria extremely short, basal, usually a single puncture or punctiform. Elytra with the dorsal stria as in the preceding subspecies. Propygidium punctate as in the preceding laterally, but with some of the discal punctures more enlarged than in the preceding forms. Pygidium as in the preceding subspecies.

Male with the anterior fossa of the thorax very shallow and poorly developed. Both sexes with anterior angles of the pronotum depressed.

Length 4.25–3.25 mm. 6 ♂♂, 16 ♀♀.

Type, allotype and paratypes in my collection.

Distribution, Enterprise, Indian River, Florida and North Carolina.

This sub-species has the propygidium more flattened and shorter in proportion to its width than any of the preceding subspecies. There is a gradual decrease in the size of these subspecies; *platysma*, *quadridentata* and *floridæ* are close together in size, and progressively smaller; *minor* is very much smaller. The measurements given above for *floridæ* and *minor* do not seem to show this, but when the average size of a series is taken it is very distinct. The average size of my series of *floridæ* is 4.75 mm., while the average size of *minor* is 4.2 mm.

Subspecies **floridæ** var. **striatifera** nov.

More narrowly oval than typical *floridæ*. Supraorbital stria moderately well defined but short. Marginal stria of thorax entire, with a very shallow semi-circular sinuation just before the middle; under this sinuation and between the marginal stria and the margin lies a short stria. Propygidium and pygidium as in *floridæ*.

Length 4.75 mm. Type in my collection.

Distribution, Florida.

This species is very variable in the number and spacing of the teeth on the lower crests of the hind and intermediate tibiæ; the commoner forms have this crest with two closely approximated teeth on the middle tibiæ, and one tooth on the hind tibiæ, or two moderately widely spaced teeth on the middle tibiæ and two closely approximated teeth on the hind tibiæ; less often we find the spaced teeth of the middle tibiæ

combined with a single tooth on the hind tibiæ. One specimen has four small teeth on the lower crest of the middle tibiæ and three on the hind; one specimen has the 4-3 condition on one side and the 2-2 condition on the other. Two specimens from Mexico have one tooth only on the lower crest of both hind and middle tibiæ.

It is reported to occur in decaying palmetto (*Sabal*) by Schwarz.

Hololepta (Leionota) decimstriata sp. nov.

Oval. Front minutely punctate; supraorbital stria entirely lacking. Mandibles as long as head, punctulate. Pronotum bisinuate at base with a very faint median striæ, which does not reach the base and extends forward past the middle; marginal stria as in *quadridentata*. Elytra longitudinally tristriate, the first stria short, basal, one-third the length of elytra, second entire, slightly arcuate, third short on the apical sixth; at the base of the elytra there is a short, deeply impressed transverse stria, equidistant from the second longitudinal stria and the scutellum. Subhumeral stria deep, rugose, abbreviated at base, reaching the basal fourth and almost reaching the apex; a series of confused punctures between the apical end of the subhumeral and the apical end of the second stria. Inflexed flanks not rugose.

Propygidium moderately convex, with large punctures laterally which grow finer towards the disk and apex; disk smooth. Pygidium with coarse, moderately dense punctures laterally, which become finer and more distant towards the center and apex.

Mentum as in *quadridentata*. Prosternum with the apex more broadly rounded than in *quadridentata*.

Length 5 mm. Type in my collection.

Distribution, Enterprise, Florida (Beutenmüller).

Hololepta (Leionota) bifoveolata sp. nov.

Oval. Front without strioles; supraorbital stria lacking or very short, punctiform; mandibles as long as the head. Prothorax with the marginal stria deeply impressed, extending around the posterior angles and interrupted slightly anterior to the middle. Just behind the interruption the margin is slightly flattened on the outer surface, producing a very slight emargination when seen from above. Elytra with two dorsal stria, the first strongly impressed, about one-third the length of the elytra, the second less strongly impressed, entire, broadening to a shallow fovea at apex. Subhumeral stria almost as in the preceding but more deeply and narrowly impressed. At a point not quite half-way between the second dorsal and the suture, there is at the base of the elytra a small area, roughened by two or three short

longitudinal lines, from which a very finely impressed line extends along the base almost to the scutellum; on each side of the scutellum on the elytra is a deeply impressed, narrow fovea, into which the light line mentioned above sometimes runs. Propygidium and pygidium as in the preceding. Mentum as in quadridentata. Prosternum broad, elevated, truncate, slightly depressed at the tip, the edges of the depression elevated. Hind tibiæ with the lower crest unidentate, middle tibiæ with the lower crest bidentate, the teeth widely separate.

Length 4 mm. Type and paratype in my collection.

Distribution, Enterprise, Florida.

Hololepta (Leionota) interrupta Marseul. Mon. p. 214, pl. 5, fig. 11. 1853.

Similar in all respects to *Hololepta quadridentata*, sp. *minor*, except that the second dorsal stria is interrupted behind the middle, and the secondary sexual thoracic fossa of the male is rather better developed. Length 4 mm.

Type locality, Cuba. Florida (2).

Two specimens from Florida (♂, ♀), I assign to this species. The male agrees with Marseul's description; the female has the second dorsal twice interrupted, in the basal third and just behind the middle. Marseul states that this species may be told from *quadridentata* by the more lightly punctate pygidium and propygidium, and the "usually" interrupted second stria. He includes this species in his key under the forms which have the second stria entire. The punctation of the pygidium and propygidium of *quadridentata* I have shown to be variable, and I should consider this form to be a variety of *quadridentata* were it not for the fact that when an entire stria is interrupted, the interruption nearly always takes place in the basal third, and the apical portion of the stria becomes shorter progressively. Neither of my specimens shows this condition; the female specimen has an interruption in the basal third, but there is a short stria between this and the more apical interruption. This condition leads me to believe that the apical interruption was the first, and the latter interruption came as it does in a variable stria.

Hololepta (Leionota) vicina Lec. Ann. Lyc. Nat. Hist., N. Y., V. p. 163. 1851.

Narrowly oblong. Front with two semi-circular strioles which may connect to form a single sinuate stria; preocular tooth moderately prominent; supraorbital stria short. Pronotum with a lateral narrow

band of distant punctures, median stria extending past the middle, marginal stria entire, broadening from the anterior third into a shallow fossa behind the anterior angle, posteriorly extending around the posterior angle to a point opposite the second stria of the elytra. Elytra with three stria, the first short, about one-third the length of the elytra, usually continued to the apex of the elytron by a series of punctures, the second entire, third a basal puncture. Propygidium evenly, moderately punctate, the punctures largest laterally, finest on disk and apex. Pygidium densely punctate. On the ventral surface of the head there is extending backward from the base of the mandibles, on the gula a carina much elevated in the anterior half, low and interrupted in the posterior half; the carinæ of both sides form a V, the center of which is evenly excavated (♂), or the posterior half of the carina is obsolete or lacking and the center of the gular plate has a raised boss just behind the mentum (♀). Prosternum narrowly truncate at apex, with a V-shaped slight depression at apex (♂), or not depressed (♀), and very slightly emarginate. Second ventral abdominal segment punctate at sides only; third and fourth distinctly punctate at sides and across middle of disk. Second segment one-third the length of third.

Length 4.25–5 mm.

Distribution, San Diego, Pasadena, Washington, California, Southern California.

Hololepta (**Leionota**) **vicina** var. **californica** nov.

Similar in all respects to *vicina* but the third elytral stria is at least half as long as the first stria, though not as deeply impressed. The propygidium is less densely punctate and the punctures are larger and more uniform in size. Length 4.5 mm.

Two specimens labelled S. California (Joutel).

Hololepta (**Leionota**) **vicina** subspecies **neglecta**. Blaisdell. III, p. 338, 1892.

Lewis Ann. Mag. Nat. Hist. XIV, p. 139, 1904.

Lewis Cat., p. 3, 1905 (in error).

Narrowly elongate. Front quadristriate; the two usual arcuate striæ are present (as in *vicina*), anterior to these are two short more or less broken striæ, which form with the arcuate stria narrow V's, the apices of which are directed outward (Pl. VI, fig. 2); preocular tooth moderately projecting, depressed; supraorbital stria short, basal. Pronotum with a lightly impressed median stria which extends from the base to the middle; marginal stria entire, extending around the posterior angle to a point opposite the third stria of the elytra, ending apically in a shallow fossa close to and within the anterior angle of the pronotum; a narrow lateral band of punctures inside the marginal stria, most dense at base, very sparse and faint at apex. Elytra tristriate, the

first stria short, basal about one-third the length of the elytra, continued to apex by a series of more or less elongate punctures, second stria entire, third punctiform; subhumeral abbreviated at base and apex. Inflexed portion of elytra slightly punctate in a short band immediately inside the marginal ridge, otherwise smooth. Propygidium punctate rather evenly, the punctures large on sides, smaller on disk and at apex. Pygidium densely punctate. Mentum concave, faintly punctate. Gula as in *vicina*. Prosternum as in *vicina*. Mesosternum sparsely punctulate. Second, third and fourth ventral abdominal segments punctate for their entire width. Second segment one-half the length of the third. Length 6 mm. Type.

Distribution, San Diego Co., Cal. (F. E. Blaisdell).

This description is drawn from the type specimen kindly sent me by Mr. Blaisdell. The species is very close to *vicina*, but is much more elongate and has a very different facies. It differs from *vicina* in the sculpture of the ventral segments, in the more convex pygidium and in the shortness of the elytra, which causes the margin of the third dorsal abdominal segment to be visible for its entire width. The type is, I believe, a male.

Hololepta (Leionota) caseyi n. sp.

Narrower and more elongate than *vicina*. Front bistriate; preocular tooth moderately prominent; supraorbital stria short. Pronotum with a narrow lateral band of punctures; median stria absent or very lightly impressed; marginal stria as in *vicina*. Elytra as in *vicina*. Propygidium coarsely and sparsely punctate, the punctures finer on disk and apex; in a few specimens the disk is almost impunctate. Pygidium densely punctate. Submentum without carinæ and the cup shaped excavation of *vicina* replaced by a Y-shaped groove. Prosternum broadly truncate, its anterior margin narrowly elevate and rugulose (Pl. VI, fig. 1). Second, third and fourth ventral segments punctate at sides, impunctate on disk. Length 4.5 mm.

Holotype and six paratypes. Holotype labelled Arizona, paratypes, Nogales, Arizona.

Genus **Iliotona** gen. nov.

More or less elongate, subdepressed. Head porrect, mandibles subequal. Tibiæ dentate, the anterior quadri posterior and intermediate tridentate. The two lower teeth of the intermediate and posterior tibiæ borne on separate processes, and all three teeth subequally spaced. Prosternum carinate, terminating apically in a sharp point.

Key To Iliotona.

Pygidium margined. Mandibles without teeth and not dilated at basal fourth. Thorax not grooved near side margin below apical third...**cacti** Lec.

Pygidium unmargined. Mandibles suddenly dilated at basal fourth, with a tooth above the dilation. Thorax near side margin slightly below apical third, with a deep transverse groove.....**beyeri** Schaef.

Iliotona cacti Lec. Ann. Lyc. Nat. Hist. N. Y., V. p. 162. 1851.
Mars. Mon., p. 400, t. 10, f. 5, 1857.
Horn. Pro. Phil. Soc., p. 275. 1873.

Oblong, parallel. Front with two shallow impressions which may contain striæ, or be punctured; supraorbital stria long. Pronotum bisinuate at base with a median longitudinal stria extending two-thirds from base towards apex. Lateral margin of pronotum punctate. Marginal stria interrupted at middle by the lateral punctures on the margin itself in a small flattened area, at the interruption of the marginal stria, a single puncture. Elytra bistriate, the first dorsal short, not reaching the middle, second entire, subhumeral moderately deep, abbreviated at base. Inflexed portion of elytra rugose. Pygidium shining on disk, opaque in a band along apex. Coarsely punctate at sides, finely or not at all on disk. Pygidium opaque, finely, rather densely punctate, the apical portion higher, shining and impunctate, thus giving a margined appearance to the pygidium.

Mentum coarsely punctured, triangularly emarginate, with an elevated line extending from the hind angles to the middle or the emargination on each side. Prosternum elevated, narrow, broadened at base, terminating acutely at apex. Length 4.5–7.5 mm.

Variants. This species is very variable in the secondary sexual characters. Mexican specimens have the fossa of the male as a single deep pit, and the disk of the propygidium in both sexes impunctate and are without frontal striæ, the place of which is taken by punctures. These specimens are also much larger than the types.

Texas specimens in my collection have the fossa of the male divided into two parts, the disk of the propygidium is punctate, and the frontal striæ are replaced by punctures.

The Leconte types from San Diego have the fossa single as in the Mexican form, the propygidium is punctate on the disk, and the frontal striæ are well marked, though short and widely separated.

Distribution, Mexico, Texas, and Southern California.

Iliotona beyeri Schæffer. Ent. News, p. 302. 1917.

Elongate. Head sparsely rather coarsely punctate, a few finer punctures intermixed, preocular spine short, indistinct, supraorbital stria distinct. Mandibles elongate, feebly curved at apex, suddenly dilated on the inner side at the basal third, above the dilation, a single obtuse tooth. Pronotum with an impressed median line extending two-thirds from base to apex; marginal stria entire; at the sides slightly below apical third, a deep sinuate transverse groove, above this

a shorter straight transverse groove, and below it a very short groove which is connected to the large one by the marginal stria; region near apical and basal angles coarsely punctate; disk smooth. Elytra bistriate, first dorsal short deeply impressed, continued to base by a series of fine punctures, second subentire, ending in confused punctures, subhumeral deep, abbreviated at base and apex. Propygidium shining on disk, subopaque at sides and apex, rather sparsely so on disk. Pygidium subopaque, finely, densely, and evenly punctate. Mentum carinate as in *cacti*. Prosternum elevated carinate, broadened at base, terminating apically in a point. Length 8.5 mm.

Santa Rosa, Lower California.

EXPLANATION OF PLATES, SECTION II.

Plate XXXI.

Fig. 1. Hololepta lucida (♂).
Fig. 2. Hololepta aequalis (♂).
Fig. 3. Hololepta populnea.
Fig. 4. Hololepta (Leionota) decimstriata.
Fig. 5. Hololepta (Leionota) interrupta.
Fig. 6. Hololepta (Leionota) bifoveolata.
Fig. 7. Hololepta (Leionota) quadridentata, ssp. floridae (♂).
Fig. 8. Hololepta (Leionota) quadridentata, ssp. minor (♀).
Fig. 9. Hololepta (Leionota) quadridentata, ssp. floridae (♀).

Plate XXXII.

Fig. 10. Hololepta (Leionota) quadridentata, ssp. minor (♂).
Fig. 11. Hololepta (Leionota) sirpus.
Fig. 12. Hololepta (Leionota) vicina.
Fig. 13. Hololepta (Leionota) pervalida (♀).
Fig. 14. Hololepta (Leionota) neglecta.
Fig. 15. Hololepta (Leionota) caseyi.

Plate XXXIII.

Fig. 16. Hololepta (Leionota) quadridentata, ssp. quadridentata.
Fig. 17. Hololepta (Leionota) yucateca, extreme variant closely resembling princeps.
Fig. 18. Hololepta (Leionota) yucateca.
Fig. 19. Hololepta (Leionota) quadridentata, ssp. platysma.

Plate XXXIV.

Fig. 20. Hololepta (Leionota) pervalida (♂).
Fig. 21. Hololepta (Leionota) vernicis (♂).
Fig. 22. Hololepta (Leionota) vernicis (♀).
Fig. 23. Iliotona beyeri.

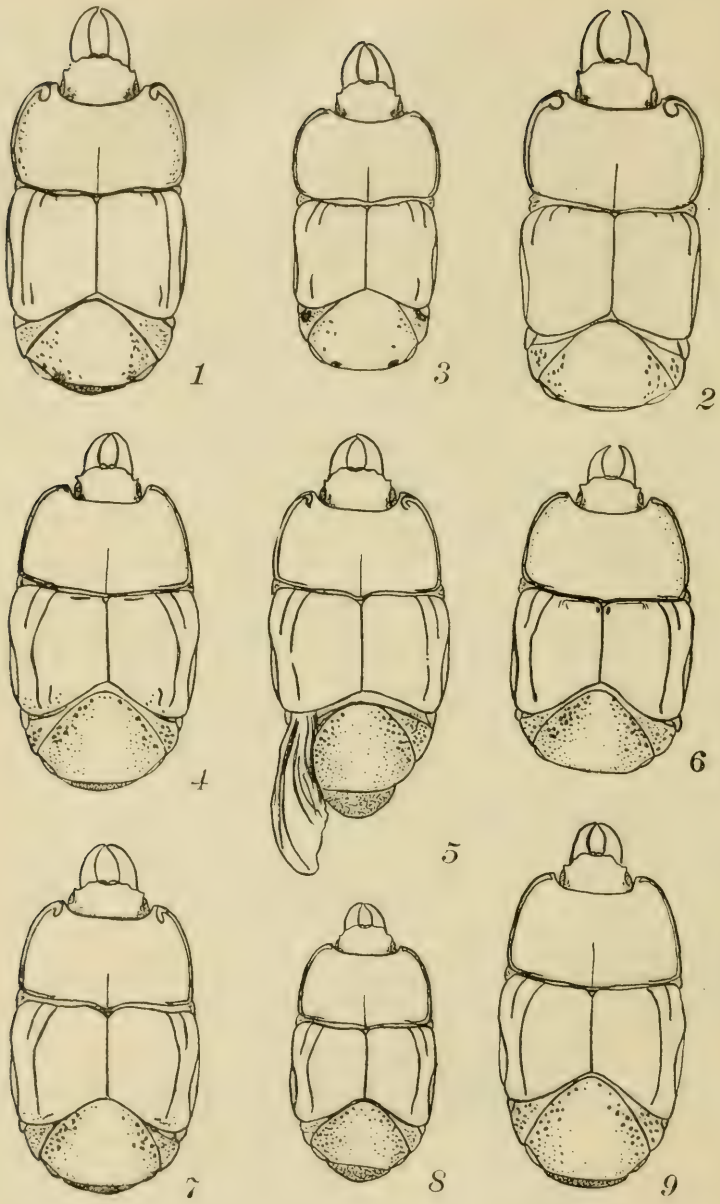
Plate XXXV.

Fig. 24. Iliotona cacti, Texas form (♀).
Fig. 25. Iliotona cacti, Texas form (♂).
Fig. 26. Iliotona cacti, Mexican form (♂).

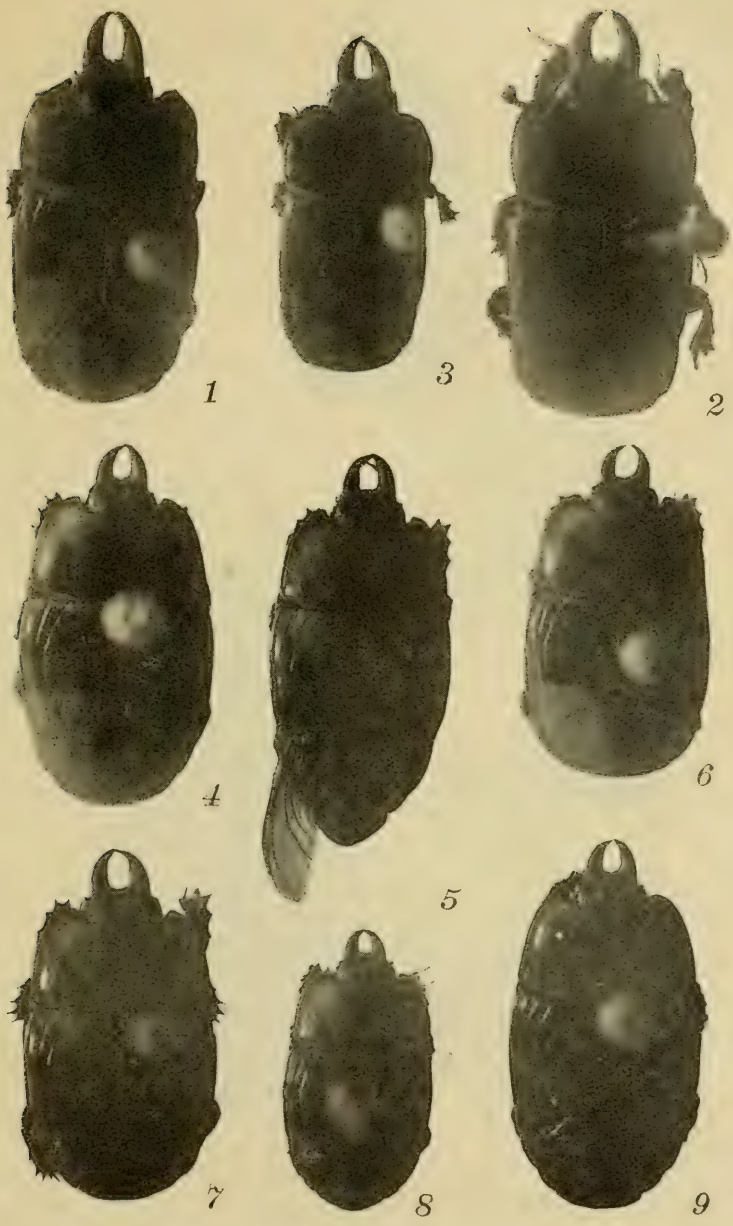
All figures are of the same magnification, about X 8.

Plate XXXVI.

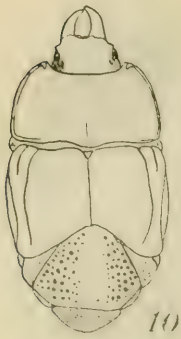
Fig. 1. Ventral view of head and prosternum of H. (L.) caseyi.
Fig. 2. Ventral view of head and prosternum of H. (L.) vicina.



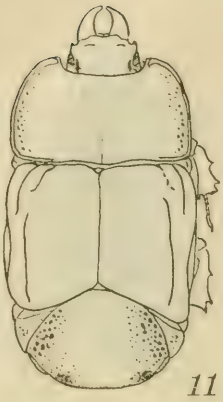
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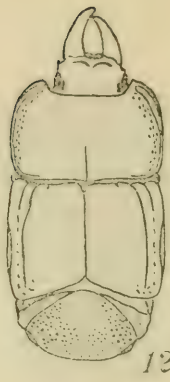
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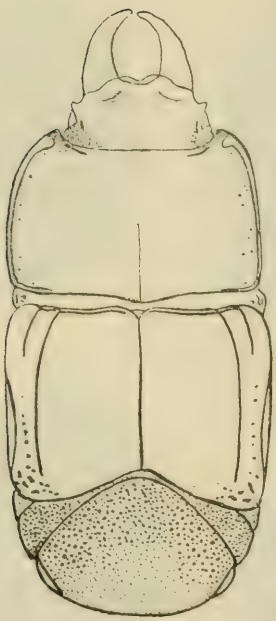
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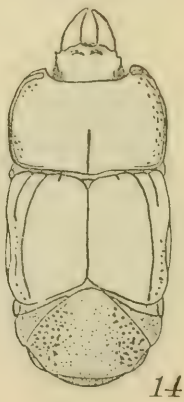
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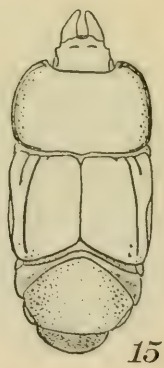
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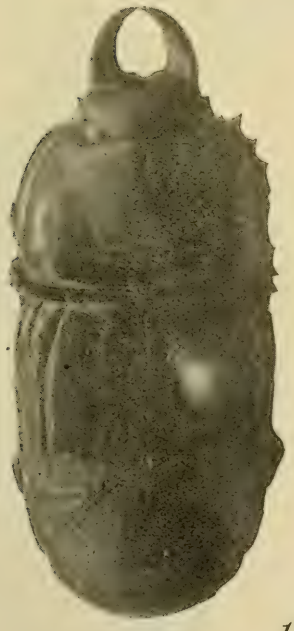
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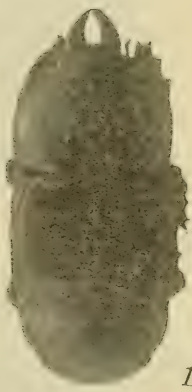
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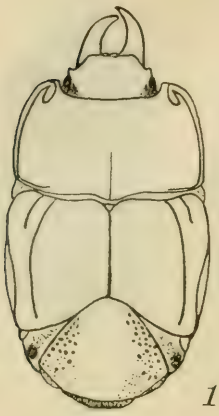


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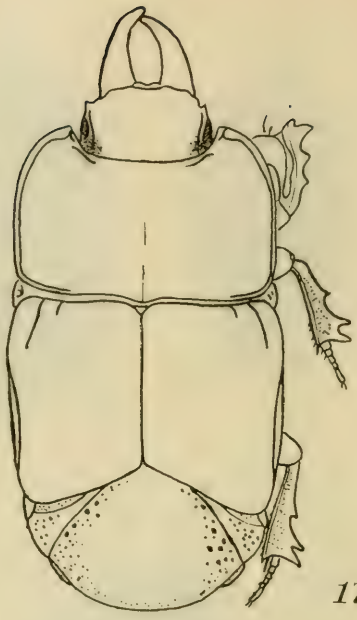


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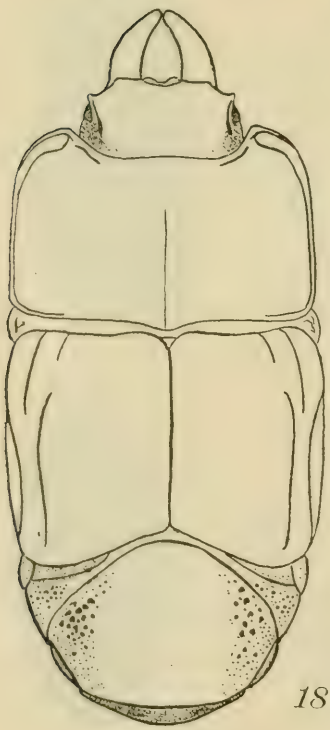
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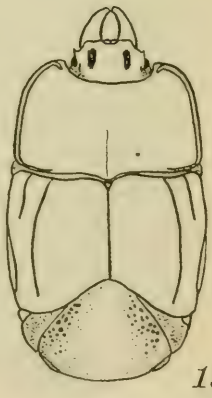
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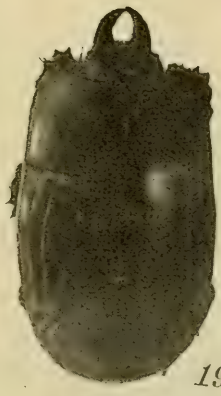
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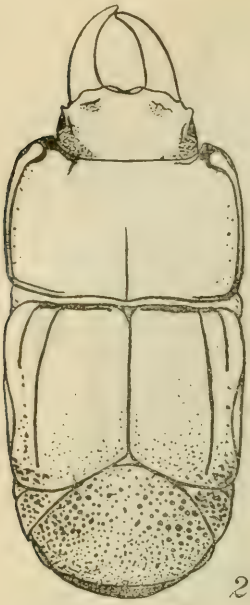


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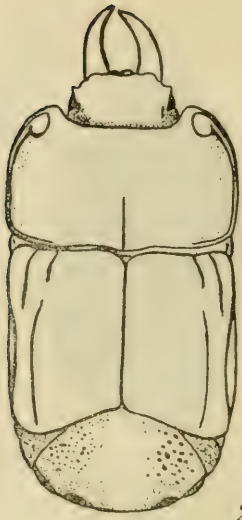


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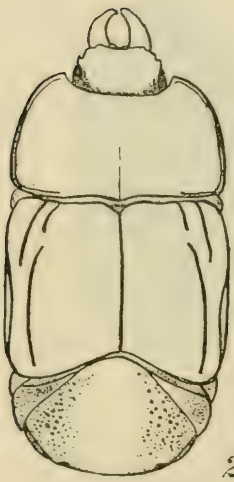
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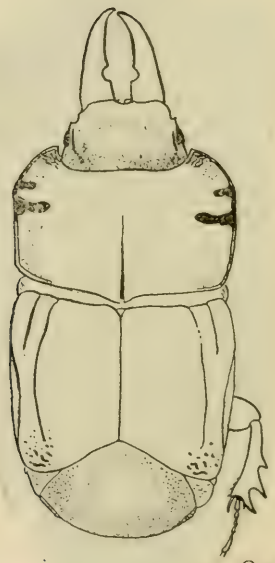
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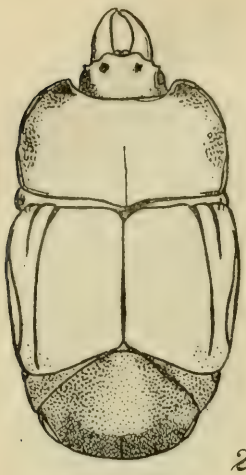


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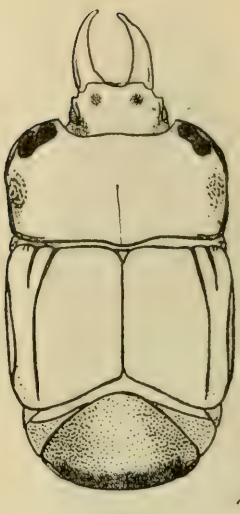


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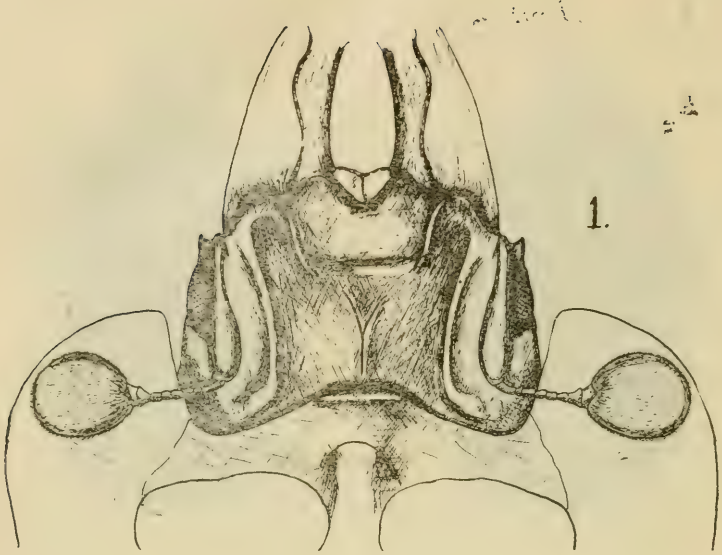


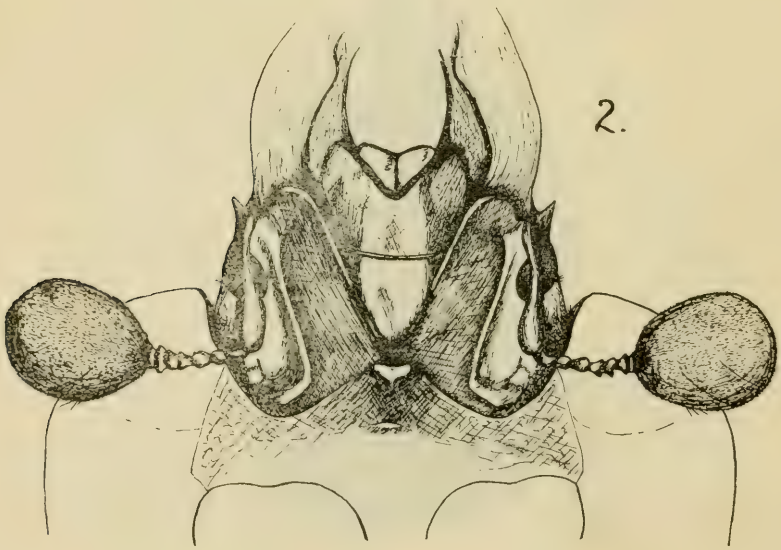
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ERRATA.

(For the June number of the "Annals," Vol. X, No. 2).

Page 126.—Figure 1 should be inverted.

Page 127.—The second footnote should read: The descriptions of this species and its genus have been sent away for publication in Part II of my series on "New Acarina."

NOTE:—The long withheld manuscript for Part II, New Acarina, unexpectedly appeared so as to ante date this paper.

PROGRAM

Annual Meeting of the Entomological Society of America, Pittsburgh, Pa., December 28 and 29, 1917

Official Hotel—William Penn
Meeting Place—Assembly Room, Margaret Morrison Carnegie School

First Session, December 28, 2:00 p. m.

Notes on the Genus Buprestis Linn. in California. . Richard T. Garnett
Studies on the Dryinid Parasites of Leaf-Hoppers. . . . F. A. Fenton
Notes on the Body Wall of the Cockroach. E. H. Dusham
Climatic and Seasonal Variation in Cerodonta. J. M. Aldrich
Observations on the Life History and Habits of *Pilophorus walshii* Uhl
Bentley B. Fulton
The Empid Genus Drapetis. A. L. Melander

Second Session, December 29, 10:00 a. m.

Business Meeting: Reports of Officers and Committees; Election of Officers; General Business.
Notes on the Early Stages and Habits of Botflies.
Seymour Hadwen and A. E. Cameron
Annotated List of Lachnosterna Enemies. J. J. Davis
The Bioclimatic Law of Latitude, Longitude and Altitude, as Applied to Entomological Research and Practice. . . A. D. Hopkins
A Systematic Study of the Organisms Distributed Under the Name of *Coccobacillus acridiorum* d'Herelle. R. W. Glaser

Third Session, December 29, 2:00 p. m.

Distribution of the Maritime Diptera of Eastern North America. .
C. W. Johnson
A Contribution to a Knowledge of the Life-History of the Leaf-eating Crane-fly, *Cylindrotoma splendens*. A. E. Cameron
Reminiscences of My Early Work upon the Diptera.
S. W. Williston, Honorary Fellow
The Hickory Gall Aphid and Its Control. Hugh Glasgow
Notes on the Genus Chlorotettix. D. M. DeLong
Some Comparisons in the Coccid Genus Chionaspis and Related Genera A. H. Hollinger
The Coccidæ of Cuba. J. S. Houser
The Alydinæ (Heteroptera) of the United States. S. B. Fracker

Fourth Session, December 29, 8:00 p. m.

Annual Address. Professor Vernon Kellogg

The Executive Committee will meet at the William Penn Hotel at 10 A. M., December 28th. The Thomas Say Foundation will meet at the William Penn Hotel at 9 A. M., December 28th.

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Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5 x 7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

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